POINT OF USE WATER TREATMENT DEVICES

ENVIRONMENTAL HEALTH APRIL 1989

CONTENTS

1. "Point Of Use Water Treatment Devices" Health & Welfare Canada; No, 60; Date-Winter 1985
2. "Activated Carbon Water Treatment Devices" Information Letter, Health Protection Branch, September 30, 1982; I.L. No.635
3. "Point Of Use Water Treatment Devices" Information Letter, Health Protection Branch, May 14, 1981; I.L. No 601.
4. "Removal Of Chemicals In Drinking Water by Point-Of-Use Treatment Devices and Associated Microbiological Problems." Environmental Health Review, Fall 1987.
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Santé et Bien-être social Canada

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POINT-OF-USE WATER TREATMENT DEVICES

Canadians are becoming concerned about the quality of their drinking water due to an increased awareness of environmental pollution and of the limitations of water treatment processes. Safe drinking water is essential to health; unfortunately, many cities are located close to sources of pollution and thus some Canadians fear for the chemical quality and safety of their drinking water.

Chemically "pure" water does not exist in nature; water is known as the universal solvent and always contains a variety of chemicals and minerals. The presence of these substances does not mean that water is not "safe," but to many people, the mere mention of chemicals in water brings to mind thoughts of pollution, disease and cancer.

A visible manifestation of the public's concern is the phenomenal rise in the sale of point-of-use water treatment devices. Current sales are at about 40 000 units annually, with a retail value of $4 million.

About half of the treatment devices sold use **activated carbon filters;** health professionals are concerned because bacteria tend to grow in carbon filters over time, which means that some water treatment devices may actually contaminate the water they are intended to purify.

HEALTH PROTECTION BRANCH

It is due to the burgeoning use and concomitant questions about safety and effectiveness of water treatment devices, that the Environmental Health Directorate of the Health Protection Branch, Health and Welfare Canada, has established a program to test and evaluate these devices. At present, such devices **are not subject to regulation** and there **are no accepted performance standards.** In general, it is considered essential that the water treated by point-of-use devices meet the quality specified in the Guidelines for Canadian Drinking Water Quality.

In Canada, provision and monitoring of most drinking water is a provincial responsibility. However, the general provisions of the federal Health and Welfare Act (Section 5) provide the basis for any research or regulatory activities carried out. For example, Canada's 1978 guidelines on drinking water quality are being revised, to take into account new scientific data and concerns since the last revision.

Water treatment devices can be classified into two groups: those used for the disinfection of water, and those which remove taste, odour and chemicals.

Educational Services, Health Protection Branch

dispatch

I DISINFECTION

Disinfection of water may be required on a continuous basis or for occasional use when microbial contamination of water may have occurred. For occasional or short-term use, there are several simple methods of disinfecting water which require no devices:

- boiling water for one minute will kill most common pathogens, but boiling for at least five minutes will ensure disinfection;
- household bleach, which contains four to five per cent sodium hypochlorite, will disinfect water when at least five drops are added to four litres of water and left to stand for 15 minutes;
- water purification tablets which release chlorine or iodine may be purchased and are especially useful for travellers when used according to manufacturers' directions.

Where disinfection of water must be carried out on a continuous basis due to dubious quality of raw water or the possibility of periodic contamination, a point-of-use device may be more practical than the short-term methods described. Efficacy, reliability, cost and maintenance requirements are all important considerations; for a review of the systems used successfully in Canada, see Table I.

For disinfection of water serving a whole house, chlorinators and ultraviolet light devices are the most practical. Chlorine generally kills disease-causing organisms and requires short to moderate contact time, depending on the amount of organic matter present. Chlorinators are widely used in large municipal systems as well as on small private systems such as wells.

Ultraviolet devices are also effective against pathogens, add nothing to water, produce no taste or odour, and in clean water require only a few seconds' exposure to be effective. The drawback is that they do not ensure safety of water beyond the point of application so that flushing of the system is recommended after periods of non-use.

Ceramic candles and iodinators handle smaller amounts of water and are useful when the water from just one tap is to be treated for drinking and cooking. Care should be taken in these cases to avoid ingestion of untreated water by using water from other taps for brushing teeth, etc. Ceramic cartridge filters consist of a cylindrical element or "candle" with a hollow centre. Water is filtered from the outside of the device to the inside, and bacteria and particulate matter is filtered through the candle pores. The candle usually contains silver which helps prevent bacterial growth through into the centre; occasional abrasion of the candle surface is required to remove material and to restore normal flow rate.

Iodinators are relatively simple devices which disinfect water by dosing an iodine solution into the main water stream. Iodine should not be used, however, for long-term continuous disinfection because the element is physiologically active and an excessive intake may be harmful.

Distillation and ozonation are suitable for use where electric power is available and there is enough space to house the apparatus. Water is boiled in a still and the vapour is condensed and collected. The process removes most metals and inorganic contaminants but it may not remove all organic materials; thus, stills may be combined with carbon filtration to achieve more complete water treatment. Ozonators produce small quantities of ozone, a strong oxidizing gas, which is effective in killing pathogens in a short exposure time, while producing no taste or odour. The process is dependent on good mixing of ozone with the water, however, and the residual effect is very short-lived.

II REMOVAL OF CHEMICAL CONTAMINANTS

It is not generally appreciated that much of Canada's drinking water is highly processed; in fact, more than a million tons of chemicals are added each year to drinking water. Despite the fact that most municipally-treated water is adequately processed, many Canadians fear the presence of harmful contaminants. It is true, too, that the chlorination of drinking water may produce low levels of halogenated by-products some of which are suspected carcinogens; this fact has spurred interest in alternative methods of water treatment. In most cases, no health risk is present, but certain aspects of the water supply in some areas may not be esthetically appealing.

Water softeners

A number of devices are available for removing chemicals and improving the quality of water. (See Table 2.) The most common type is the water softener; its main function is to remove calcium and magnesium from "hard" water. While softening water makes it more suitable for washing and prevents deposits in appliances and pipes, the water is not generally recommended for drinking or cooking due to its increased sodium content, decreased essential mineral content and the potential of bacterial growth.

Carbon filters

Carbon filters are more effective in removing organic chemicals from water than inorganic; they are often used to remove taste, odour, chlorine and hydrogen sulphide and may be combined with other treatment processes.

The principal disadvantage of activated carbon filters (including those which contain silver) is their ability to foster bacterial growth on the trapped organic substances, and to release those bacteria into the water. It is imperative then that these filters be used only on water which meets guidelines for microbiological safety, and that these filters be flushed each day before use.

Another disadvantage is the variability in removing organic contaminants from water; research has indicated as well that the efficiency of these filters with regard to some contaminants decreases with use.

The risk of using activated carbon filters can be lowered by following these steps:

* use only with microbiologically safe water
* flush for at least 30 seconds before use
* change filters frequently
* follow manufacturers' advice for installation and service.

Others

As already mentioned, both distillation and reverse osmosis processes remove chemical contaminants such as heavy metals, but they are not totally effective against organic contaminants. In addition, reverse osmosis membranes are not highly efficient at water pressures normally encountered.

STORAGE OF WATER

Ideally, treated water should be consumed immediately after treatment to prevent deterioration. Some types of bacteria can grow in almost any water, especially at warm temperatures; if water is not to be used right away, it may be stored for no more than a few days in the refrigerator. Home treatment devices should be flushed for 30 seconds after a period of non-use, overnight for example. Water that is stored in tanks at room temperature - in boats and campers, for example - poses a special problem. Storage tanks should be cleaned and disinfected periodically, and the water replaced; disinfection of the water may be necessary to ensure safety.

CHOOSING A WATER TREATMENT DEVICE

Advertising claims for a given point-of-use water treatment device are an important factor in the selection of a device by most consumers. For this reason, it is essential that claims accurately represent the performance of the product. Tests of such a device carried out for the manufacturer by reputable laboratories can be useful in evaluating the claims made for it; often, however, these tests may be incomplete or insufficiently described to be useful. If there is any doubt about the effectiveness of the device, advice should be sought from provincial health or environment officials who are the experts in this field.

In conclusion, it is important for health professionals advising consumers about the safety and effectiveness of point-of-use water treatment devices to understand the following points:

* the specific contaminant in the water supply must be known in order to choose the most effective treatment process

* most point-of-use devices are intended for use only on municipally-treated water, not "raw" untreated water

* activated carbon filters can pose a significant risk to health if used improperly.

Health professionals should enquire about the use of such devices when seeing clients or patients who exhibit symptoms of gastroenteritis.

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80-EHD-54 - Assessing the effectiveness of small filtration systems for point-of-use disinfection of drinking water supplies.

Available from:

Environmental Health Directorate
Health Protection Branch
Ottawa, K1A 0L2

Table 1. **Devices for disinfection of water**

Type	Advantages	Limitations	Special Requirements
Ceramic Candles	Inexpensive, simple	May not be effective against viruses	
Chlorination	Proven technology	May require additional filters to remove protozoan cysts	Residual test kit, electricity
Distillation	Effective against all pathogens	Batch system - water may not be available when required	Electricity
Iodination	Inexpensive	May require additional filters to remove cysts. Possible physiological effects of iodine	Residual test kit
Ozonation	Low operating cost	May require additional filters to remove cysts. Iron, sulphur and manganese must not be excessive	Electricity
Ultraviolet Light	Uses no chemicals	May require additional filters to remove cysts	Electricity, UV monitor

Table 2. Devices for taste, odour and chemical removal

Type	Advantages	Limitations	Special Requirements
Activated Carbon	Removes taste, odour, organics, chlorine, low levels of hydrogen sulphide	Should be used on microbiologically safe water	Cartridges should be changed regularly
Chlorination	Iron, manganese, hydrogen sulphide removal		Electricity, filter to remove precipitates
Distillation	Removes inorganic salts, some organic chemicals, particles, hydrogen sulphide	May concentrate some organic chemicals	Electricity
Green Sand Filters	Iron, manganese, hydrogen sulphide removal	May clog or reduce effectiveness due to bacterial growth	Backwash and regenerate regularly, replace media
Particulate Filters	Turbidity, particle removal		
Reverse Osmosis	Inorganic salts removal	Susceptible to clogging	Adequate water pressure, flush
Softeners	Hardness (calcium, magnesium) removal	Elevates sodium content; possible bacterial growth	Usually require electricity

ÉGALEMENT DISPONIBLE EN FRANÇAIS SOUS LE TITRE
"DISPOSITIFS DE TRAITEMENT DE L'EAU AU POINT D'UTILISATION"

Information Letter

Lettre de renseignements

Health Protection Branch

Direction générale de la protection de la santé

September 30, 1982 I.L. N° 635

TO: Manufacturers and Distributors of Water Treatment Devices

SUBJECT: Activated Carbon Water Treatment Devices

SUMMARY

Information Letter No. 601 issued on May 14, 1981, outlined a proposal to prohibit, under the authority of the Hazardous Products Act, the sale of activated carbon devices not associated with a disinfection process.

This proposal was based on the demonstrated growth of waterborne bacteria, including some potentially harmful to man, on the activated carbon filters.

In response to Information Letter No. 601, the Branch received 16 submissions containing specific comments regarding the proposal. While some of the submissions affirmed the growth of bacteria on activated carbon filters, an association between the use of activated carbon filters and adverse health effects has not been conclusively demonstrated.

Trade associations, representing manufacturers of water treatment devices, have been responsive to Health Protection Branch concerns and have agreed to request that all members ensure their activated carbon filters are not used on microbiologically unsafe waters, or with waters of unknown quality. Where undisinfected private well water is used without activated carbon filters, the associations have agreed to request members to caution consumers to monitor the water periodically for coliform and other potentially hazardous organisms. These actions will effectively remove the main concerns of the Health Protection Branch that were stated in Information Letter No. 601.

Le 30 septembre 1982 L.R. N° 635

AUX: Fabricants et distributeurs de dispositifs de traitement de l'eau

OBJET: Dispositifs de traitement de l'eau à charbon actif

RÉSUMÉ

La Lettre de renseignements n° 601, parue le 14 mai 1981, présentait une proposition visant à interdire, en vertu de la Loi sur les produits dangereux, la vente de filtres à charbon activé qui ne font pas partie d'un système de désinfection.

Il a en effet été démontré que des bactéries qu'on trouve dans l'eau, notamment certaines potentiellement nuisibles à l'homme, prolifèrent sur les filtres de charbon actif.

À la suite de l'envoi de la Lettre de renseignements n° 601, la Direction générale a reçu en tout 16 réponses écrites commentant la proposition. Même si des réponses confirment la prolifération microbienne sur les filtres à charbon actif, on n'a pu établir la preuve d'un lien entre l'utilisation des filtres à charbon actif et les effets défavorables pour la santé.

Les associations commerciales, représentant les fabricants de dispositifs de traitement de l'eau, ont été sensibles aux préoccupations de la Direction générale de la protection de la santé et ont consenti à demander à tous leurs membres de s'assurer que leurs filtres à charbon actif ne sont pas utilisés pour filtrer des eaux à concentration bactérienne élevée ou de qualité inconnue. Dans le cas des eaux non désinfectées provenant de sources privées (eaux de surface ou de puits) et traitées ou non au charbon actif, les associations ont accepté de demander à leurs membres de recommander aux consommateurs d'effectuer périodiquement des numérations de coliformes et d'autres organismes dangereux pour la santé. Ce faisant, ces interventions soulageront les inquiétudes principales exprimées par la Direction générale de la protection de la santé dans la Lettre n° 601.

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In view of the agreement to ensure proper use of activated carbon filters, the Health Protection Branch considers that further action on the proposal to prohibit the sale of such devices under the authority of the Hazardous Products Act is not warranted at this time.

1. INTRODUCTION

Information Letter No. 601, dated May 14, 1981, proposing to prohibit the sale of point-of-use water treatment devices containing activated carbon and not part of a disinfection system, was sent to all manufacturers and distributors of water treatment devices as well as trade associations, provincial governments, embassies and special interest groups. Approximately 500 copies were distributed initially and about 200 further copies were distributed at the request of individuals and companies.

A total of 16 written responses have been received from various segments of society with an interest in these devices. The sources of the responses were as follows:

Source of Response	Number
Individuals responding on their own behalf	3
Government	3
Trade Association	1
Manufacturers or distributors	8
University Faculty Member	1
TOTAL	16

The responses can be divided up into those making specific comments on one or more of the following subjects:

- supportive comments and evidence for the proposed ban;
- requirement of activated carbon filters for health effects;
- statement of insufficient evidence of adverse health effects;
- submission of additional test data.

En vertu de l'entente visant la bonne utilisation de ces filtres, la Direction générale de la santé considère que d'autres mesures dans le sens de la proposition d'interdire la vente de ces dispositifs en vertu de la Loi sur les produits dangereux seraient actuellement prématurées.

1. INTRODUCTION

La Lettre de renseignements n° 601, datée du 14 mai 1981 et proposant d'interdire la vente de dispositifs de traitement de l'eau au point d'utilisation à charbon actif et sans désinfection, a été envoyée à tous les fabricants et distributeurs de dispositifs de traitement de l'eau, ainsi qu'aux associations professionnelles, aux gouvernements provinciaux, aux ambassades et à des groupes qui ont des intérêts spéciaux. Au début, on a distribué 500 exemplaires de cette lettre et 200 autres exemplaires ont été envoyés à la demande de particuliers et de sociétés.

On a reçu au total 16 réponses écrites émanant de divers segments de la société intéressés par ces dispositifs. Les répondants se répartissent comme suit:

Répondants	Nombre
Particuliers	3
Administration gouvernementale	3
Association commerciale	1
Fabricants et distributeurs	8
Universitaire	1
TOTAL	16

Les répondants ont présenté des remarques précises sur au moins un des sujets suivants:

- remarques et données en faveur de l'interdiction proposée;
- besoin de filtres à charbon actif, pour raisons de santé;
- déclaration d'une insuffisance de preuves étayant les effets nocifs pour la santé;
- résultats de tests supplémentaires.

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The remainder of this Information Letter will be devoted to a summary and assessment of the comments received pursuant to the issuance of Information Letter No. 601.

2. SUPPORTIVE EVIDENCE

Two respondents concurred that these devices posed potential health hazards and supported the proposed ban. A third respondent agreed that there was a need to control these and other point-of-use water treatment devices, but suggested that development of voluntary standards should be considered as an alternative to the proposed ban.

A respondent in the water engineering industry stated that activated carbon filters should only be installed at the recommendation of qualified public health engineers after examining microbiological and chemical analyses of the water where disinfection is not employed.

A respondent who sells several types of water treatment devices supported the ban and emphasized that many persons and companies selling such devices are not qualified to recommend appropriate water treatment.

A respondent with university affiliation indicated that he had also found extensive bacterial growth on activated carbon in research studies carried out on potable water treatment. It was noted that several of the bacterial genera were representatives of opportunistic pathogens to man.

Another respondent expressed support for the proposed ban, indicating that they were aware of the microbiological growth on activated carbon filters, and their product had incorporated an ultraviolet lamp in the system to disinfect the water, thereby eliminating this problem.

3. REQUIRED FOR HEALTH REASONS

Two respondents stated they were allergic to chlorine in water and have found symptomatic relief by the use of activated carbon filters on their tap water. They expressed their wish to continue to use

Le reste de la présente Lettre de renseignements sera consacré à un résumé et à l'évaluation des observations reçues à la suite de l'envoi de la Lettre de renseignements n° 601.

2. DONNÉES À L'APPUI

Deux répondants estiment que ces dispositifs peuvent présenter des risques et appuient l'interdiction proposée. Un troisième répondant convient qu'il faut contrôler ces dispositifs, ainsi que d'autres qui traitent l'eau au point d'utilisation, mais il suggère des normes volontaires plutôt que l'interdiction proposée.

Un ingénieur en hydrologie estime que les filtres à charbon actif ne devraient être installés que sur recommandation d'ingénieurs sanitaires, après analyse microbiologique et chimique de l'eau, en l'absence de désinfection.

Un répondant qui vend plusieurs dispositifs de traitement de l'eau se déclare en faveur de l'interdiction et souligne que de nombreuses personnes et sociétés qui vendent ces dispositifs n'ont pas la compétence voulue pour recommander le traitement de l'eau qui s'impose.

L'universitaire fait savoir qu'il a également décelé une croissance bactérienne considérable sur le charbon activé au cours de travaux sur le traitement de l'eau potable. On a remarqué que plusieurs des genres de bactéries étaient représentatifs de pathogènes opportunistes pour l'homme.

Un autre répondant a pris parti pour l'interdiction proposée, soulignant qu'il est au courant de la prolifération microbiologique sur les filtres à charbon actif et que le dispositif qu'il produit comporte une lampe à ultra-violets pour désinfecter l'eau, éliminant ainsi le problème.

3. DEMANDE DE FILTRES À CHARBON ACTIF, POUR RAISONS DE SANTÉ

Deux répondants signalent qu'ils sont allergiques au chlore; les filtres à charbon actif installés aux robinets ont soulagé leurs allergies. Ils souhaitent continuer à utiliser ces filtres pour

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activated carbon filters for chlorine removal. A third respondent felt that the public should be able to purchase and use devices to remove particular chemicals from water if they are sensitive to them or deem them a health hazard. Thus, it was stated, methods should be developed to control bacterial growth on activated carbon.

The Health Protection Branch recognizes that activated carbon is useful in the removal of certain tastes and odours as well as some organic chemicals in contaminated aquifers. Depending on the exact nature of the problem, activated carbon in association with disinfection or other techniques could be used, such as distillation of water, using reverse osmosis devices or purchasing bottled water.

4. STATEMENT OF INSUFFICIENT EVIDENCE OF ADVERSE HEALTH EFFECTS

A submission received from a trade association stated that the proposed ban was "neither necessary nor justifiable because there is no demonstrable potential health hazard arising from the proper use of such products and, thus, no need from a public health standpoint for such a ban". The main thrust of the argument against the proposed ban was made in the following areas:

- bacteria are everywhere in the environment and food;
- there is no correlation between standard plate counts and waterborne disease;
- activated carbon filters have never been implicated in any waterborne disease case during 50 years of use;
- the bacteria isolated in water from activated carbon filters (including Pseudomonas aeruginosa and Flavobacterium) are not significant to human health;

éliminer le chlore. De son côté, un autre répondant estime que les gens devraient pouvoir acheter et utiliser des dispositifs pour éliminer certains produits chimiques contenus dans l'eau s'ils y sont allergiques ou s'ils estiment que ces substances menacent leur santé. Ces répondants sont donc d'avis que l'on devrait mettre au point des méthodes pour enrayer la prolifération bactérienne sur le charbon actif.

La Direction générale de la protection de la santé reconnaît que le charbon actif élimine bien certains goûts et certaines odeurs, ainsi que certains produits organiques présents dans la nappe aquifère. Selon la nature particulière du problème, on pourra envisager des mesures complémentaires à l'utilisation du charbon actif, comme distiller l'eau, utiliser l'osmose inverse, ou encore, se limiter à l'eau embouteillée.

4. PREUVES INSUFFISANTES ÉTAYANT LES EFFETS NOCIFS POUR LA SANTÉ

Une association commerciale soutient que l'interdiction proposée n'est "ni nécessaire, ni justifiable, parce qu'on ne peut démontrer aucun risque pour la santé découlant d'une utilisation adéquate de ces produits et que, par conséquent, cette interdiction n'est pas nécessaire du point de vue de l'hygiène publique". Les principaux arguments présentés contre l'interdiction sont les suivants:

- on trouve des bactéries partout dans l'environnement et les aliments;
- il n'y a pas de corrélation entre la numération standard sur plaques et les maladies transmises par l'eau;
- on n'a jamais incriminé les filtres à charbon actif à propos des maladies transmises par l'eau, depuis 50 ans qu'on les utilise;
- les bactéries isolées de l'eau sur les filtres à charbon actifs (notamment Pseudomonas aeruginosa et Flavobacterium) ne portent guère atteinte à la santé;

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- the benefits of using activated carbon filters (taste, odour and chemical removal, and use of the superchlorination-dechlorination process of disinfection) outweigh any disadvantages of their use.

The Health Protection Branch recognizes that bacteria are ubiquitous in the environment and that Standard Plate Counts or other general plate count methods do not measure all bacteria in a given sample, nor are harmful organisms a constant fraction of the bacteria enumerated. It is clear, however, that some primary pathogens and many opportunistic pathogens are among those bacteria that can be enumerated by the standard plate count method. Furthermore, increased numbers of bacteria indicate decreased water quality and a higher probability of finding opportunistic pathogens in significant numbers. Some of the organisms found capable of growth on activated carbon can be harmful to man.

It is true that no documented case of illness has been reported that has been associated with the use of activated carbon filters. Many of the types of illness that could reasonably be expected to result from the types of bacteria that can proliferate on activated carbon are mild, self-limiting and non-notifiable. Thus it is unlikely that any such illness would be discovered and traced to its source. Conversely, many of these organisms are important causes of nosocomial and other infections in man, and thus their presence in drinking water should be minimized. It is noted that exposure to infectious agents in water is not only through drinking of water but may also be by food washing or preparation; washing wounds; eyes, ears; showering and bathing; use in humidifiers or sick-room vaporizers; preparation of infant food or drink.

- les avantages offerts par l'utilisation de filtres à charbon actif (élimination des goûts, des odeurs et des produits chimiques), et l'utilisation du procédé de désinfection par surchloration et déchloration l'emportent sur les inconvénients.

La Direction générale de la protection de la santé reconnaît que l'on rencontre des bactéries partout, que la numération standard sur plaques, comme d'autres méthodes générales de numération sur plaques, ne démontre pas toutes les bactéries d'un échantillon et que les bactéries nuisibles ne sont pas toujours dans la même proportion des bactéries énumérées. Cependant, il est clair que certains pathogènes primaires et de nombreux pathogènes opportunistes se trouvent parmi les bactéries qui peuvent être énumérées au moyen de la numération standard sur plaques. De plus, l'accroissement du nombre des bactéries signale une détérioration de la qualité de l'eau et rend très probable la présence de nombreux pathogènes opportunistes en nombre suffisant. Certains des organismes capables de proliférer sur le charbon actif peuvent être des pathogènes pour l'homme.

Il est vrai qu'on n'a signalé aucun cas documenté de maladie reliée à l'utilisation de filtres à charbon actif. Nombre d'affections qu'on pourrait raisonnablement prévoir des genres de bactéries pouvant proliférer sur le charbon actif sont bénignes, évoluent spontanément, et leur déclaration n'est pas obligatoire. Il est donc peu probable que ces maladies seraient découvertes et qu'on pourrait remonter à leur source. Réciproquement, un grand nombre de ces organismes sont une cause importante d'infections nosocomiales et d'autres infections chez l'homme et il faut donc abaisser leur concentration dans l'eau potable. On remarque, d'autre part, que l'on n'est pas exposé aux agents infectieux seulement lorsqu'on boit l'eau, également lorsqu'on l'utilise à toutes sortes de fins: laver ou préparer les aliments, nettoyer des plaies, irriguer les yeux et les oreilles, servir aux douches, aux bains, à l'humidification des chambres de malades et à la préparation des aliments ou boissons pour bébé.

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5. SUBMISSION OF ADDITIONAL TEST DATA

Five respondents from industry submitted additional test data on bacteriological testing of activated carbon filters. Each of these submissions will be summarized briefly below:

(i) One respondent submitted data on in-home tests of 4 filters and 4 faucets without filters. Total coliform and standard plate counts were sometimes higher in the control faucets than in the test filters. Another study showed that faucets and sink sprayers can develop high standard plate counts after periods of non-use. It was concluded in this submission that the devices were microbiologically neutral and did not present any risk of illness.

(ii) A respondent submitted limited tests with a filter that incorporated a hot backflush step periodically. Backflushing did lower standard plate counts temporarily, but no data on the regrowth rate were shown.

(iii) A respondent submitted test data on the effect of a silver-containing activated carbon filter on *E. coli*, coliforms, *Staphylococcus aureus* and plate count bacteria. It is claimed that the filter can be used when *E. coli* are present up to 100 per 100 mL in the water; however, the results presented indicated the effluent did not meet the maximum acceptable concentration for coliforms as stated in *Guidelines for Canadian Drinking Water Quality 1978.*

(iv) A respondent submitted test data on coliform and standard plate count bacteria removal by the powdered

5. DONNÉES SUPPLÉMENTAIRES

Cinq répondants du secteur privé ont envoyé des résultats de tests bactériologiques de filtres à charbon actif. On en trouvera ci-après un bref résumé:

(i) Un répondant a envoyé des données sur les tests effectués à domicile sur 4 filtres et 4 robinets non munis de filtres. Le total des bactéries coliformes et les numérations standard sur plaques ont parfois donné des chiffres plus élevés avec les robinets témoins qu'avec les filtres. D'après les résultats d'une autre étude, les robinets et les gicleurs pour éviers peuvent donner des numérations standard sur plaques élevées après des périodes de non utilisation. Le répondant en a conclu que les dispositifs étaient neutres au point de vue microbiologique et qu'ils ne présentaient pas de risque de maladie.

(ii) Un autre répondant a présenté des tests limités effectués avec un filtre incorporant un jet d'eau chaude à refoulement périodique. Le refoulement a effectivement abaissé temporairement les résultats des numérations standard sur plaques; on ne disposait pas de données sur la vitesse avec laquelle les bactéries proliférèrent par la suite.

(iii) Un répondant a présenté des données sur les tests effectués sur l'effet du filtre a charbon actif contenant de l'argent sur *E. coli*, les coliformes, *Staphylococcus aureus* et sur l'énumération de bactéries. On prétend que le filtre peut être utilisé lorsqu'on trouve jusqu'à 100 *E. coli* par 100 mL dans l'eau; toutefois, les résultats présentés indiquent que les eaux de sortie contiennent plus de coliformes que la concentration maximale acceptable spécifiée dans la publication "Recommandations pour la qualité de l'eau potable au Canada, 1978".

(iv) Un répondant a présenté les résultats de tests effectués sur l'élimination des coliformes et des bactéries

...7

rather than granular activated carbon filter with a unique design and 1 μm particle retention. Data presented show an average of 99.3% removal of a coliform challenge over a 19-day period. Another set of data submitted showed standard plate count bacteria proliferation in both the activated carbon filter and in plumbing fixtures as well.

(v) A respondent submitted test data on an activated carbon filter containing metalic silver, intended to act as a bacteriostatic agent to prevent bacterial growth in the filter. In these extensive tests, control filters containing no silver were subject to high bacterial growth as demonstrated by standard plate counts. None of the silver-containing devices showed elevated plate counts during the test period.

The Health Protection Branch does not consider the test data from the silver-containing devices to be valid because of a serious deficiency in the test protocol. In none of the tests was there any indication that silver in the effluent from the filter was neutralized before plating for bacterial determination. If this step is omitted, the stress of silver ions in the medium for the 48 hour test adversely affects bacterial enumeration. Further, these results are in disagreement with other studies that have failed to show the effectiveness of silver in preventing bacterial proliferation in activated carbon.

6. CONCLUSIONS FROM SUBMISSIONS

The Health Protection Branch concerns for the potential health hazard presented by the use of activated carbon filters were documented in Information Letter No. 601. The responses to the Information Letter

énumérées (numération standard sur plaques) par un filtre de conception originale, à charbon actif en poudre plutôt que granulaire, et rétention de particules de 1 μm. Les données présentées indiquent, en moyenne, une élimination de 99,3% de la charge en coliformes, sur une période de 19 jours. Une autre série de résultats indique une prolifération de bactéries (numération standard sur plaques), tant sur le filtre à charbon actif que dans les appareils de robinetterie.

(v) Un répondant a présenté les résultats de tests effectués sur un filtre à charbon actif contenant de l'argent métallique, comme agent bactériostatique, pour éviter la prolifération des bactéries dans le filtre. Au cours de ces tests approfondis, les filtres témoins qui ne contenaient pas d'argent présentaient une prolifération bactérienne active, comme l'indiquent les numérations standard sur plaques. Aucun des dispositifs contenant de l'argent n'a donné des numérations standard sur plaques élevées au cours de la période d'essai.

La Direction générale de la protection de la santé n'estime pas que les données sur les tests effectués à partir des dispositifs contenant de l'argent sont valides, à cause d'une grave lacune dans le protocole expérimental. En effet, dans aucun des tests, on n'a indiqué que l'argent présent dans les eaux de sortie du filtre était neutralisé avant la numération des bactéries. Si cette étape est omise, la présence de l'ion argent dans le milieu pendant les 48 heures de l'épreuve affaiblit des bactéries. De plus, ces résultats ne concordent pas avec ceux d'autres études qui n'ont pas réussi à démontrer l'efficacité de l'argent en ce qui concerne la prévention de la prolifération bactérienne dans un filtre à charbon actif.

6. CONCLUSIONS TIRÉES DES RÉPONSES

Nos inquiétudes concernant les filtres à charbon actif ont été exposées avec une documentation à l'appui dans la Lettre de renseignements n° 601. Les réponses reçues à la suite de l'envoi de cette lettre ont

...8

have increased the knowledge of the extent and magnitude of bacterial growth on such filters. Conversely, no evidence for illness or harm from the use of activated carbon filters has been found. In view of the significant questions raised regarding the health implications of the use of such filters on municipally-treated, disinfected water, a decision was made to convene a group of experts in a workshop format, to identify the gaps in knowledge regarding the adverse human health potential posed by the various uses of activated carbon filters and to determine how these gaps could be best addressed by further research. At the present time no further action is contemplated on the proposal to prohibit the sale of these devices under the authority of the Hazardous Products Act. However, it is considered that activated carbon filters must not be used where the water is microbiologically unsafe or with waters of unknown quality. Where the devices are used on an undisinfected source, such as a private well, periodic bacteriological monitoring for coliforms and other health-related organisms should be carried out to ensure the safety of the effluent water.

enrichi les connaissances sur l'importance de la prolifération bactérienne dans ces filtres. Par ailleurs, on n'a pas fait la preuve que l'utilisation des filtres à charbon actif était nocive. Compte tenu des questions importantes soulevées à propos des incidences sur la santé de l'utilisation de ces filtres sur l'eau désinfectée et traitée par la municipalité, on a pris la décision de réunir un groupe d'experts, en atelier, en vue de déceler les lacunes des connaissances concernant les effets nocifs pour les humains, présentés par les diverses utilisations de filtres à charbon actif et de déterminer quels travaux pourraient le mieux permettre de combler ces lacunes. Présentement on n'envisage aucune autre mesure dans le sens d'une interdiction de la vente de ces dispositifs en vertu de la Loi sur les produits dangereux. Cependant, on estime que les filtres à charbon actif ne doivent pas être utilisés lorsque l'eau contient trop de microbes ou lorsque sa qualité est inconnue. Lorsque ces dispositifs traitent une eau non désinfectée, comme celle d'un puits privé, on devrait effectuer une numération périodique des coliformes et d'autres organismes avec implications pour la santé, pour vérifier l'innocuité de l'eau de sortie.

Le Sous-ministre adjoint,

A.B. Morrison, Ph.D.,
Assistant Deputy Minister.

Information Letter
Lettre de renseignements

Health Protection Branch
Direction générale de la protection de la santé

May 14, 1981 I.L. No. 601

TO: Manufacturers and Distributors of Water Treatment Devices

SUBJECT: Point-of-Use Water Treatment Devices

The Health Protection Branch has been involved in the testing of point-of-use water treatment devices for over three years. In that time, we have investigated the efficacy and potential microbiological problems of many devices, including those containing activated carbon to remove taste and odours and specific substances.

Recently, concern has arisen about the safety and efficacy of point-of-use filters containing granular activated carbon and used to treat water for drinking purposes. In the course of testing the devices, we have determined that a potential health hazard can arise due to bacterial growth on the carbon bed of the filters. (See attached documentation). Consequently, in order to eliminate this potential health hazard, I propose to recommend that steps be taken under the authority of the Hazardous Products Act to prohibit the sale of "point-of-use devices that are used in the household for the treatment of potable water and that contain activated carbon, granular activated carbon, or charcoal; but not including those devices that disinfect water after it passes through the carbon bed". For these purposes, the bacteriostatic action of silver is not considered to be disinfection.

Le 14 mai 1981 L.R. N° 601

AUX: Fabricants et distributeurs de dispositifs de traitement de l'eau

OBJET: Dispositifs de traitement de l'eau au point d'utilisation

Depuis trois ans, la Direction générale de la protection de la santé a soumis à des essais des dispositifs de traitement de l'eau au point d'utilisation. Au cours de cette période, nous avons examiné, pour ce qui est de l'efficacité et des problèmes microbiologiques potentiels, de nombreux dispositifs, dont ceux qui contiennent du charbon activé pour enlever le goût, l'odeur et des substances particulières.

Les aspects sécurité et efficacité des filtres au point d'utilisation, contenant du charbon activé granulé et servant à traiter l'eau en vue de la rendre potable, ont récemment soulevé des inquiétudes. En mettant à l'essai ces dispositifs, nous avons pu déterminer qu'ils présentent un risque sanitaire potentiel dû à la croissance de bactéries sur la couche de charbon des filtres. (Voir la documentation ci-jointe). Dans le but d'éliminer ce risque sanitaire potentiel, je me propose donc de recommander que des mesures soient prises en vertu de la Loi sur les produits dangereux pour interdire la vente de "dispositifs au point d'utilisation utilisés à domicile pour le traitement de l'eau de boisson et contenant du charbon activé, du charbon activé granulé ou du charbon de bois; mais non des dispositifs qui désinfectent l'eau après son passage à travers la couche de charbon". A ces fins, l'action bactériostatique de l'argent n'est pas considérée comme désinfectante.

... 2

You are invited to review this proposal and forward any comments and evidence within two months from the date of this Letter to the Director, Bureau of Chemical Hazards, Environmental Health Directorate, Health Protection Branch, Tunney's Pasture, Ottawa, Ontario, K1A 0L2.

Vous êtes priés d'étudier cette proposition et d'envoyer tout commentaire ou fait pertinent, dans un délai de deux mois à compter de la date de publication de la présente lettre, au Directeur, Bureau des dangers des produits chimiques, Direction de l'hygiène du milieu, Direction générale de la protection de la santé, Parc Tunney, Ottawa, Ontario, K1A 0L2.

Le Sous-ministre adjoint,

A.B. Morrison, Ph.D.,
Assistant Deputy Minister

Attachment

Pièce jointe

THE HAZARDS OF USING POINT-OF-USE WATER TREATMENT DEVICES EMPLOYING ACTIVATED CARBON

BUREAU OF CHEMICAL HAZARDS
ENVIRONMENTAL HEALTH DIRECTORATE
HEALTH PROTECTION BRANCH
HEALTH AND WELFARE CANADA
DECEMBER 1980

Activated carbon is often employed in point-of-use water treatment devices or "purifiers". It is sometimes claimed that they remove tastes and odours, chlorine, sediment, organic and inorganic chemicals, carcinogens, toxic substances, and other contaminants usually with little or no evidence to substantiate the claims. Where test data are available, they are usually limited to a single challenge with no attempt to determine the operating parameters over the expected lifetime of the device. Because of the known problem of bacterial growth on activated carbon beds, some products are formulated with silver to release low levels of silver ions to act as a bacteriostatic agent. Most of the activated carbon-containing filters are designed to be used exclusively on treated municipal water rather than on untreated (raw) water; the exceptions are those filters used in "super-chlorination - dechlorination" bactericidal systems (1) and at least one activated carbon device that has bactericidal claims (2) and is intended for treating raw waters.

As the filter is used, water passes through the activated carbon bed and some of the organic material in the drinking water is concentrated on the surface of the activated carbon particles within bed. As the same time, bacteria occurring in the water (3) are concentrated by depth filtration and can utilize the organic material for a nutrient supply (4). Growth is particularly favoured at warm room temperature at low water flow rates and periods of non-use (i.e. overnight or longer). The bacterial growth is of concern for three reasons: Total bacterial numbers (standard plate counts) can be elevated, coliform bacteria can be encountered and grow on the filters, and pathogenic bacteria may colonize and proliferate on the filters. The evidence for each of these occurrences and their significance is discussed separately.

Growth of Bacteria

Wallace and coworkers (5) were among the first to demonstrate the excessive growth of bacteria on activated carbon filters. They found bacterial levels of up to 70,000/mL within 6 days of installing a new filter. Fiore and Babineau (6) obtained high levels of bacteria in the first flush after overnight stagnation, but maintained that these were not significantly higher than influent levels after periods of stagnation. Two other studies (7,8) showed high total bacterial counts after the filters had been in use for several days. Studies carried out by the Bureau of Chemical Hazards on several types of activated carbon devices have shown elevated counts in the effluents from the devices on both raw (2) and finished (1, 9-11) drinking water. Tobin et al (11,12) reported on simulated lifetime testing of three activated carbon devices. During the first few days in service, the filters were effective in removing bacteria from water, but effluent counts gradually increased until they reached a plateau at about 25 days. With a chlorinated drinking water containing a background level of 160 colonies/mL, the first samples taken from the three devices after overnight stagnation contained geometric means (day 25-55) of 85,000, 40,000 and 162,000 colonies/mL. A paired silver-containing unit actually had higher bacterial numbers in the effluent than the non-silver containing control. The United States Environmental Protection Agency commissioned a study on activated carbon units and showed similar results. The seven brands of filter yielded maximum values on first flush samples of 190,000, 120,000, 320,000, 240,000, 20,000, 120,000 and 130,000 (13). Among these, devices containing silver did not consistently effect bacteriostasis in their tests.

The "standard plate counts" used in these studies enumerate the "normal" flora of drinking water, although certain pathogens can be enumerated among them. The bacteria in the finished drinking water can originate by passing through the treatment plants in flocs or turbidity, or by being entrapped in crustacea and nematodes or may come from bird droppings in reservoirs, biological growth near the edges of tanks or reservoirs, sediment pockets in distribution systems and pipe sections, cross connections, loss of line pressure or line breaks or repair (3). According to Geldreich et al (3), finished water may at various times contain Pseudomas, Flavobacterium, Achromobacter, Proteus, Klebsiella, Bacillus, Serratia, Corynebacterium, Mycobacterium, Spirillum, Clostridium, Arthrobacter, Gallionella, and Leptothrix. This list contains several pathogens and secondary pathogenic invaders. It has been shown on actual water system surveys that the pathogen Pseudomonas aeruginosa was present in 77.3% of the cases where the standard plate count was over 100/mL (14). While these may not give rise to a serious hazard when present in very low numbers or on a sporadic basis, their proliferation and concentration in the effluent of a filter are cause for immediate concern.

In Europe, the colony count in finished drinking water is often the primary microbiological criterion for its acceptance. In Germany the maximum limit is 100 colonies/mL; sudden increases in the plate counts which have been low for several years have preceded the onset of disease in certain cases (36). Such increases occurred prior to the typhoid outbreaks in Elsenkircheau in 1889, in Pforzhein in 1919, and in Hanover in 1926. In the Hanover case, the colony counts were elevated for several days prior to the appearance of coliforms in the drinking water (36). The recommended and mandatory limits for colony counts in drinking water in Europe are given in Table 1.

Another basic problem with elevated standard plate counts is a reduction in the sensitivity of the total coliform test for drinking water quality. Several species of bacteria commonly found among the standard plate count bacteria have been identified as coliform antagonists (37). When the plate count reaches the critical value of 1000/mL (3), total coliform results are unreliable. An upper limit of 500/mL has been suggested for drinking water in the U.S.A. (3, 38) and in Canada it is considered to be the upper limit for community water supplies that do not employ disinfection (5). The Guidelines for

Canadian Drinking Water Quality 1978 state:

> "Where a municipality is unable to distribute water to the consumer's taps with a total bacterial count of less than 500/mL, then chlorination or other satisfactory form of treatment should be instituted to meet this objective".

Total Coliform Bacteria

In addition to growth of the general bacterial population, recent studies have demonstrated the ability of total coliform bacterial to colonize activated carbon filters (11, 12, 16). In contrast to earlier reports that could not demonstrate coliform growth (6, 17), one study (16) showed the filter to emain contaminated 7 days after influent levels of coliforms were non-detectable. Another study (12) revealed that the bacteria persisted at least 9 days after a transient contamination occurred in the municipal tap water. Subsequent intentional contamination of the water in laboratory tests confirmed the ability of sewage coliforms to survive and proliferate on activated carbon filters. In this case, however, a silver-containing bacteriostatic unit was shown to eliminate the total coliform counts, confirming the differential sensitivity to silver ions. The sensitivity of another coliform, *Escherichia coli* to low levels of silver ions in water has already been shown (16). Thus, the primary drinking water quality indicators (total coliform organisms) are inactivated by silver in the units, while the general bacterial population, possibly including pathogenic bacteria, is not affected. In both situations, that is, where coliforms proliferate on activated carbon, or are nactivated by silver-containing activated carbon filters, an accurate assessment of the water quality by means of coliform tests cannot be made. Furthermore, the proliferation of coliforms and general bacterial population does raise questions regarding which pathogenic organisms can be expected to grow as well.

Pathogenic Bacteria

In the course of the three-year testing program undertaken by the Bureau of Chemical Hazards, several instances of contamination of the filters by pathogenic organisms were observed (9, 1, 12). When water was allowed to flow slowly through an activated carbon filter on a continuous basis (effluent temperatures 12°C), a constant plate count of about 50 colonies/mL was obtained. Pigmented bacteria among these were identified as a Flavobacterium species (9). Pseudomas aeruginosa was present in the effluent at a level of 3-6 colonies/100 mL and were not detectable in the influent municipal treated water. In a study of three brands of filters (11, 12), P. aeruginosa were isolated from the effluents of each. It is noteworthy that growth of coliforms and Pseudomonas on hydrocarbon-exhausted activated carbon has been used as a method of bioregeneration (35). P. aeruginosa is a pathogen of major importance and should not be present in drinking water (18, 19). Greer and coworkers (20) considered that P. aeruginosa in drinking waters could not be ignored and its isolation should condemn a water for drinking purposes. Several outbreaks of gastrointestional illnesses have been attributed to drinking water contaminated with P. aeruginosa (18). It is also the cause of persistent ear and urinary infections (21, 22). Seyfried and Fraser (23) determined that P. aeruginosa persisted in swimming pool water containing 0.4 mg/L free available chlorine and also demonstrated ear infection in 4 of 24 people swimming in a pool containing less than 80 organisms/100 mL (24). In hospitals, this organism is particularly dangerous for those who are immunologically impaired, burn cases, and those undergoing surgery (19, 22, 25-28). It has caused epidemics of diarrhea in a nursery for newborn in which several children died (29). Flavobacterium is also a pathogen of some importance for newborn. It has been identified as the pathogenic agent in an epidemic of meningitis of newborn

(30) and is a pathogen for patients undergoing surgery as well (31). In one hospital study (32), the upper airway of 195 patients were colonized by Flavobacterium that were ultimately traced back to the water supply. In considering pathogens, it is well established that there is a minimum infective dose for each pathogen below which very few persons will become ill. In most cases, sporadic or transient contamination of drinking water will result in concentrations below this dose. It is the possibility of exacerbation, by growth of this organism on filters, that is a cause for concern (16). Some persons such as the aged and very young infants may also have significantly lower resistance to the pathogens. The many uses of water such as preparing baby foods and formula, humidifying sick-rooms, washing wounds, bathing and showering, all present different opportunities for infection to occur.

Removal of Chemicals

The evidence presented here indicates there is a potential adverse effect from the use of activated carbon devices on the microbiological quality of water. In addition to the microbiological problems, however, studies of chemical removal have shown that the devices often give unsatisfactory removal of trihalomethanes, total organic carbon (purgeable and non-purgeable), and total available chlorine (11, 13, 33). The limited efficacy coupled with the problem that the consumer has no means whereby he can determine whether the filter's effective lifetime has been exceeded, indicate that these devices are not particularly useful nor desirable in the home. Further, the Guidelines for Canadian Drinking Water Quality, 1978 (15) and provincial legislation outline the requirements that must be met by municipally-treated water. These guidelines are designed to produce a healthy, aesthetically-pleasing water that should not have to be further treated in the home. Taylor, Allan and Geldreich (33) of the U.S. E.P.A. recently concluded after an in-depth study of activated carbon devices:

> "Ultimately, the water consumer should not have to make the decision to treat his water at the point-of-use. It is the water industry's combined responsibility to provide an adequate, reliable and healthful drinking water so that the consumer does not feel it necessary to redo at home what has already been done professionally at the treatment plant."

Potential for Misuse

The above discussion relates to the application of filters to municipally-treated water only. When they are misapplied to raw, untreated water from ground or surface sources, the danger is even greater. Organic materials and bacteria, including pathogens, are usually present at significantly higher levels than in treated water and this can lead to very rapid contamination of the filters and effluent waters. A recent study of an activated carbon device, purported to have bactericidal properties, showed excessive contamination of the water from the first to the fortieth day of the test (2). Total coliform counts of 4000 to 7300/100 mL were obtained, while 10/100 mL in a single sample is the maximum permitted in finished drinking water (5). It has come to the attention of the Bureau of Chemical Hazards that some of the activated carbon devices have been sold for use on raw water even when clearly labelled that they must only be used on municipally-treated water. The potential for growth of pathogens is so great under these conditions that every effort should be made to prevent this hazard.

Conclusions

A review of the scientific literature has shown that bacteria, including bacteria pathogenic for man, proliferate on activated carbon filters that have been in use for several days or weeks. These pathogenic organisms have been implicated in serious illness and death of susceptible individuals, including w-born, immunologically-deficient individuals, and burn and surgery patients. Otherwise healthy individuals may be susceptible to ear or upper respiratory tract infections. A petition made to the Product Safety Commission in the United States that proposed to ban carbon-only filters (34) was denied. According to documentation received from this hearing, the sole basis for the denial of the petition was that "present data do not support the contention that there is a bacterial build-up on the filter". The additional data reviewed here clearly establish such a build-up of bacteria. The evidence is considered to be adequate documentation of a significant health risk to humans by use of these devices on municipally-treated water. The opportunity for misuse of these devices by treating raw water further increases the risk. Activated carbon filters should not be used for the treatment of potable water unless adequate disinfection of the water after filtration is carried out prior to consuming the water.

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TABLE 1 - Colony Count; Recommended or Mandatory Values in Europe (35).

Country	Recommended Value/ mL	Mandatory Value/ mL	Temperature	Comments
Poland	. . .	25	. . .	
Czechoslovakia	. . .	20	37°C	
	. . .	100	20°C	public supply
	. . .	100	37°C	
	. . .	500	20°C	well water
Yugoslavia	. . .	10	37°C	for treated water
	. . .	100	37°C	raw underground water
	. . .	300	37°C	raw surface water
Romania	. . .	20	. . .	public water supply for 70 000 consumers
		100 to 300	. . .	other supplies
Switzerland	. . .	100	. . .	raw water entering works
		300	. . .	raw water during distribution
		20	. . .	treated water immediately after treatment
		300	. . .	treated water in distribution system
Spain	. . .	50 to 65	37°C	good quality water
		100	37°C	tolerable quality water
Netherlands, Sweden, GDR	. . .	100	20°C	
Federal Republic of Germany Disfected water	20	. . .	20 ± 2°C	
All other kinds of drinking water	100	. . .	20 ± 2°C	
Water tanks	1000	. . .	20 ± 2°C	
Bottled waters	. . .	1000	20 ± 2°C	
France, Austria, Great Britain	. . .	. . .	. . .	no guide or imperative values

Removal of Chemicals in Drinking Water by Point-of-Use Treatment Devices and Associates Microbiological Problems

Photo by Bob Hart

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W. J. Robertson

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The increasing public concern with regard to the chemical purity of drinking water in Canada has resulted in the burgeoning use of point-of-use treatment devices. These are small home appliances used to treat drinking water just prior to consumption. Approximately 100,000 of these devices are sold annually in Canada.

These are two situations where consumers may wish to use chemical-removal devices. A device may be appropriate when it has been established by competent health authorities that an individual's private water supply is contaminated with toxic or aesthetically objectionable chemicals. In this case professional assistance and continued monitoring of the raw and treated water is required. Secondly an individual may believe that the local municipal drinking water would benefit from additional treatment in the home in order to remove taste, odour, or dissolved chemicals. In such a case, routine monitoring of the water treated in the home is not necessary since it should already meet the appropriate guidelines or standards for potable water quality.

Although these devices are used to treat one of our most important resources, there is currently no legislation or regulation in Canada governing their use or effectiveness. It is important for public health inspectors to recognize the limitations and potential problems associated with these products and to be able to competently advise the public on the suitability of various devices to correct perceived or actual problems.

Processes employed for chemical removal include filtration on activated carbon, reverse-osmosis, ozonation and distillation. While ozonation and distillation can also be effective at reducing microbiological contamination, activated carbon and possibly reverse-osmosis can contribute to the numbers of microorganisms in water.

Activated carbon filters

Activated carbon filters are the most common devices on the market accounting for approximately 70% of sales of point-of-use treatment devices. They are relatively inexpensive, widely available and highly promoted for the removal of odour, taste and chemicals in drinking water. They are not suitable for the removal of dissolved salts. Usually they consist of a replaceable carbon cartridge mounted in a plastic or stainless steel housing. The majority are designed for in-line attachment to the cold water supply in the kitchen, but some include a bypass and separate tap solely for drinking water. Other units available connect directly to the tap, or rest on the counter and attach to the tap by a hose.

Each of the devices regardless of how effective they are at removing chemicals, have associated microbiological problems.

The efficiency and life expectancy of a unit depend on several factors such as water flow rates, concentration of contaminants, filter temperature, volume of water processed and the quantity of activated carbon in the device. The small tap-mounted devices usually contain about 5 g of granular activated carbon while the majority of larger units contain between 200 and 800 g of granular, powdered or compressed activated carbon. Under high flow rates and corresponding short contact times the relatively small amount of carbon in such filters can not remove all the contaminants present. A summary of various efficacy studies carried out in Canada and the USA is presented in Table 1. The removal of chlorine is generally good. improving the odour. taste and colour of the water. but the removal of total organic carbon (TOC) and trihalomethanes (THM) varies widely depending on the design and characteristics of a particular unit. Some studies (Taylor **et al.** 1979) have demonstrated that the capacity of a filter to remove THM quickly diminishes with time and in some instances (after at least 18 weeks) filters can even increase the THM concentrations in the drinking water. Thus it must be recognized that the life expectancy of a filter may vary for different organic compounds and that a "slug" of higher concentrations of organic compounds may be flushed from the filter into the drinking water. Few of the activated carbon devices currently available incorporate any means of alerting users when the filter should be replaced. Although knowledgeable authorities recommend replacement at monthly intervals. users should at least follow the manufacturer's replacement guidelines.

Ozonation

In the past ozone has been used predominantly for disinfecting water supplies. but is now being increasingly promoted as an oxidant of organic compounds responsible for colour. odour and taste problems in water. While coloured humic materials are partially oxidized to simpler colourless compounds such as ketones and aldehydes. inorganic chemicals responsible for aesthetic problems (e.g. ferrous iron and hydrogen sulphide) are oxidized to insoluble products that can be removed by filtration.

In a typical household ozone generator. air passes between two charged electrodes and the resulting high tension voltage discharge converts a small fraction of the oxygen in the air (1% by weight. under optimal conditions) into ozone. Unlike commercial units. household units are normally not equipped with air-driers and high relative humidities are known to reduce the production of ozone. Moreover. since ozone has a short half-life and quickly reverts back to oxygen. the oxidation of organic compounds in water is often incomplete and such compounds may remain in the water (Rice. **et al.** 1981). Household units are usually equipped with post-ozonation activated carbon filters to improve the removal of organic compounds.

Reverse-Osmosis

In the past few years membrane technology has improved to such an extent that it is now possible to operate reverse-osmosis devices at municipal water distribution pressures. These units typically consist of a spiral-wound semi-permeable cellulose acetate membrane cartridge and are used to remove particulate matter. microorganisms and dissolved inorganic salts. Cations such as sodium are particularly well removed. but these devices are not as effective at removing certain organic compounds or anions (eg. nitrates) (Table 2). Many devices include either compounds such as THM and CCl_4 (Table 2).

Although these devices are used to treat one of our most important resources, there is currently no legislation or regulation in Canada governing their use or effectiveness.

None of the devices currently available include any means of alerting the user to the rupture of the membrane or surrounding seals. Such a break or tear could permit contaminants to enter the treated water. Another major disadvantage of these devices is their poor water-use efficiency. Usually only about 10% of the water is purified. the remaining 90% is wasted to a drain after flushing the membrane. Some units do. however. employ a recycling device that increases the efficiency to 20-50%.

Distillation

In addition to disinfecting water. stills are commonly employed to reduce the levels of chemicals in drinking water. The units usually consist of a pyrex glass or stainless steel boiler fitted with an immersion heater. an air cooled condenser and a reservoir for the distillate. Since many contaminants are at least as volatile as water. one drawback of the process is the possible co-distillation of these contaminants with the water. Manufacturers. recognizing these problems. have incorporated several features to prevent volatile organic compounds from being carried over with the distillate. Features include granular activated carbon filters. vents in the condenser. or fractional distillation (preheating water before entering the boiling chamber).

Associated Microbiological Problems

Each of the devices described above. regardless of how effective they are at removing chemicals. have associated microbiological problems. The potentially most serious problems occur with activated carbon filters. As several studies have demonstrated. bacteria initially removed from the water accumulate on the carbon and multiply using the absorbed organic material as substrates (Taylor et **at.** 1979. Tobin **et at.** 1981. Bell **et at.** 1984. and Geldreich **et al.** 1985). As little as 5 days after installation these bacteria. begin to slough off the filter and increase the concentration of bacteria usually expressed as colony forming units (CFU)/ml of potable water (Figure 1). The rate and extent of growth can not be easily predicted but depend on many interacting factors such as water temperature. surface area of carbon. contact time. concentration of bacteria initially present. concentration of biodegradable chemical contaminants. efficiency of chlorine removal. and length of time the filter has been in use. This problem is particularly noticeable after stagnation periods as short as 8 h. Concentrations of bacteria in the filtered water can be as much as 2000 times higher than in the non-filtered water. For this reason it is highly recommended that. prior to consuming the water. units should be flushed for at least 30 seconds. Some manufacturers have included silver in the activated carbon in an attempt to reduce microbial growth. but in most studies the effectiveness of silver for this purpose has not been confirmed (Tobin **et al.** 1981. Bell **et al.** 1984). Such "bacteriostatic" filters should never be considered capable of disinfecting polluted water.

Bacteria naturally present in treated drinking water are not considered hazardous at the concentrations at which they are usually present. However any practice that increases their concentrations should be avoided. At elevated concentrations certain species (eg. **Pseudomonas aeruginosa**) are opportunistic pathogens, and present a hazard to the very young, the elderly and immunosuppressed persons who may have lower than normal resistances to infection. In several studies the potential for the growth of coliform bacteria and certain pathogens on these filters has also been examined (Tobin et al. 1981. Regunathan et al. 1983. Geldreich et al. 1985. Camper et al., 1985.

Information on the removal of **Giardia lamblia** cysts by activated carbon devices is scarce. **Giardia lamblia**, a protozoan intestinal parasite, is currently the primary cause of gastroenteritis in water-associated disease outbreaks. As few as 10 cysts ingested can produce giardiasis (Rendtorff, 1954). One manufacturer of compressed activated carbon block filters states in the accompanying owner's manual that their device is capable of removing **Giardia** cysts from water. On the other hand recent studies have demonstrated that devices containing granular activated carbon are not effective in this regard (manuscript in preparation).

Ozone has proved to be an effective means of destroying bacteria and **Giardia** cysts (Katzenelson et al. 1974. Wickramanayake et al. 1985). However point-of-use ozonators employing post-ozonation activated carbon filtration could introduce problems. Depending on the design of the unit, microorganisms could absorb on the filter, resist ozonation and recontaminate the treated water as illustrated above.

Reverse-osmosis devices are susceptible to similar problems. Although the pores in these units are small enough to remove all microorganisms, some can pass through microscopic size breaks in the membrane and colonize the activated carbon filter and treated water reservoir (Regunathan et al. 1983). Recently it was demonstrated (manuscript in preparation) that when a reverse-osmosis unit was challenged with **Giardia** cysts, cysts and bacteria were recovered in the purified water. This suggests that a break in the membrane had allowed accumulated cysts and bacteria to pass into the permeate. Unfortunately there are currently no practical means of knowing when microscopic-

TABLE 1. Chemical Removal by Activated Carbon Devices

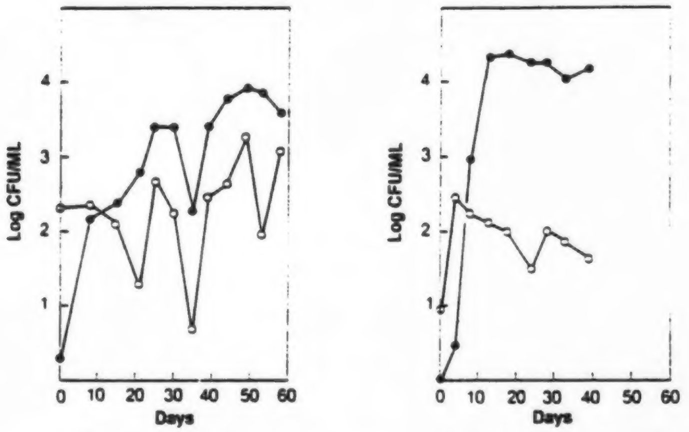
Unit	Chemical	% Removal	Source
Tap-mounted	FAC	> 75	Tobin et al. 1981
	TAC	66	Tobin et al. 1981
	TOC	11-16	Tobin et al. 1981
	TOC	6-18	Bell et al. 1984
	THO	76-97	Bell et al. 1984
	THM	6-69	Bell et al. 1984
In-line	FAC	>75	Tobin et al. 1981
	FAC	52-97	Taylor et al. 1979
	TAC	50-66	Tobin et al. 1981
	TOC	4-33	Tobin et al. 1981
	TOC	7-12	Bell et al. 1984
	THO	90	Bell et al. 1984
	THM	15-46	Bell et al. 1984
	THM	50-100	Taylor et al. 1979
Line bypass	TAC	>80	Health and Welfare Canad (unpublished)
	TOC	>60	Health and Welfare Canad
	TOC	6-87	Bell et al. 1984
	THO	97-99	National Sanitation Foundatio 1985
	THO	95	Bell et al. 1984
	THM	23-99	National Sanitation Foundatio 1985

1. FAC - free available chlorine; TAC - total available chlorine; TOC - total ganic carbon; THO - total halogenated organics; THM -trihalomethanes.

TABLE 2. Chemical Removal in a Reverse-Osmosis Activated Carbon Devic (Regunathan et al. 1983)

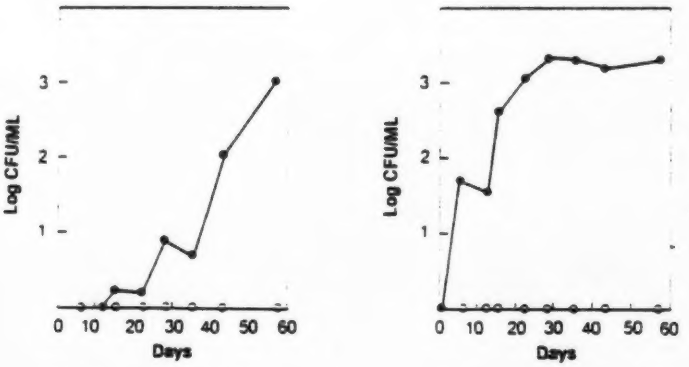
Chemical	Removal
Sodium	82
Sulphate	98
Nitrate	40
TOC	99-100
THM	90-100

Fig. 1 Bacterial concentrations in activated carbon filtered (●) and non-filtered drinking water (○); first flush after overnight stagnation (tested by Health and Welfare Canada)



a) Tap mounted granular carbon dioxide

b) Countertop pressed carbon device



c) Silver impregnated granular carbon device

d) In-line granular carbon device

ized ruptures have occurred: thus water containing potentially hazardous concentrations of cysts and/or bacteria could be consumed.

In stills, boiling the water quickly destroys any microorganisms which may be present. However it has been demonstrated that the condensers, tubing and reservoirs can become contaminated with ubiquitous **Pseudomonas** sp. which thrive on any trace nutrients that may be carried over into the distillate. Distilled water stored for extended periods at room temperature should not be considered sterile.

In view of the above shortcomings, all of the above devices with the exception of stills should only be used to treat water that is already microbiologically safe for human consumption.

Under high flow rates and corresponding short contact times the relatively small amount of carbon in such filters can not remove all the contaminants present.

Assessing the Various Devices

In light of the above information there are four factors which must be considered before recommending a particular device.

1) Will it solve the problem being experienced without creating additional potentially more serious problems?
2) Are the efficacy claims by the manufacturer for the removal of contaminants supported by actual test data obtained by a creditable laboratory?
3) Are the manufacturer and seller reputable and knowledgeable?
4) Is the total cost of the device including replacement filters, membranes etc. commensurate with the effectiveness of the device?

In North America there are several public and private laboratories and organizations that can evaluate various devices. Among these are Health and Welfare Canada, Consumer and Corporate Affairs Canada and in the USA the Environmental Protection Agency. Another organization, the National Sanitation Foundation, has developed test protocols to substantiate claims made by water treatment device manufacturers. In addition, they can provide a list of the various devices that have been tested and found effective in the removal of specific contaminants.

In conclusion, it must be emphasized that these devices are not panaceas. In order to function properly and at the same time minimize the potential associated hazards they must be properly selected, well-maintained and regularly monitored.

Acknowledgements

We thank Dr. R. Cullimore, Regina Water Research Institute and D. K. Smith, Ontario Research Foundation, for their important contributions to these studies.

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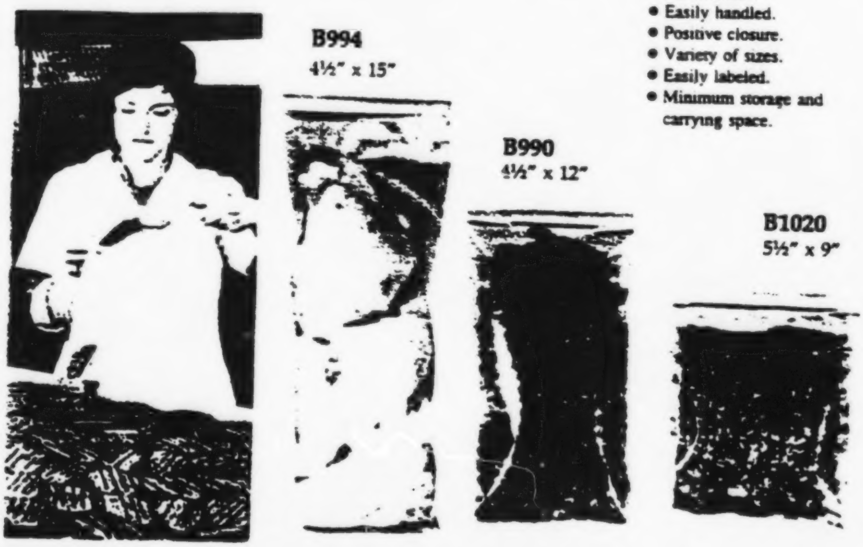

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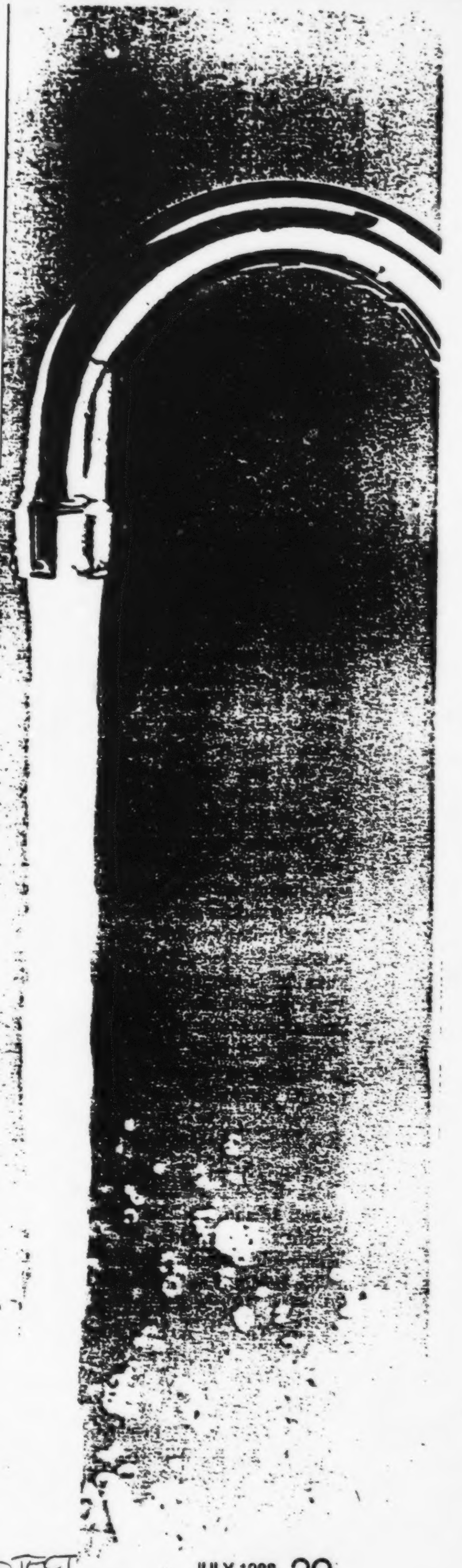
Home Water Treatment

Many consumers wonder about the quality of their water. Are home treatment devices necessary, and do they work?

by Pierre René de Cotret



Household water purifiers are currently enjoying brisk sales. The choice is broad, with some 30 models available costing from $20 to $1,800. The problem for the consumer is manyfold: does your water need treatment, how effective are home water treatment devices and, if they work, how should you choose among the multitude of types and models available?

A Taste of Water

Various solutions are open to consumers who have doubts about the quality of their water supply, or whose water has a bad taste. One is to buy bottled water. This can easily cost $250 a year, however, and dealing with the bottles is an inconvenience. A household water treatment device may be the answer.

Choosing one is another matter. Water treatment is a complex question and the operating principles of the various devices available are a mystery to most people. Needless to say, all vendors of such devices claim that their product is best — and that the water you drink is a real poison!

One Step at a Time

To decide intelligently whether or not you need water treatment and, if so, to choose a method of treatment, you must first understand the pollutants that must be eliminated. You should also consider the operating principles and purifying capacity of each type of water treatment device.

We will first examine water pollution and the various pollutants, then look at the main types of treatment devices in order to establish what kinds of pollutants each one can eliminate. Only then can we seriously present the advantages and disadvantages of the 28 particular devices we tested.

Our test focuses solely on devices designed to treat drinking water; none of those we examined is suitable for filtering or softening water for the entire house. All of the filters have fairly limited flow rates and are intended to improve the quality of drinking water, which is only 0.5 per cent of total domestic water consumption. Every person in fact needs at least two litres of water per day, which makes at least eight litres for a household of four. Add to this five or six litres for cooking, and you will need to treat roughly 15 litres of water per day, if everyone is at home and does not substitute store-purchased drinks for water.

Is Tap Water Safe?

The fundamental question is, can you trust the water that comes out of the kitchen faucet? Unfortunately, the answer basically depends upon one's point of view. This response may seem evasive, but it does reflect current scientific knowledge on the question. No one can offer absolute proof that water from municipal sources is unsafe, but neither can anyone prove beyond a shadow of a doubt that the foreign matter drinking water contains is entirely harmless. One is forced to consider the price an individual or society is prepared to pay to eliminate or reduce the risk.

Chlorination and strict control methods have made it possible to eliminate virtually all harmful microbes in our water. At one time, thousands of people suffered from typhoid fever, cholera and dysentery;

Photo: [illegible] Charland

PROTECT
YOURSELF

today, these diseases have almost completely disappeared. Modern water treatment plants generally produce clear, odour-free water (aside from the smell of chlorine). Periodic analyses are conducted to detect noxious substances, and if problems arise, authorities promptly notify the public to boil their water or stop consuming it altogether.

But while traditional water treatment processes are highly effective at dealing with certain types of contamination, roughly 20 years ago it became evident that most existing water treatment plants could not deal with the levels of chemical pollution that had begun to appear.

Should we be concerned? Absolutely, some people reply. There are all sorts of reasons to fear water from municipal sources. (See "Canada's Drinking Water" in *Protect Yourself*, October, 1985.) More than 2,100 artificial chemical products have been found in water, and the list grows longer with each passing year. Treatment plants are not equipped to detect these new pollutants, even less to eliminate them. Existing standards and controls are aimed at no more than a hundred of these substances.

Of course, it can be argued that these pollutants are highly diluted — quantities are expressed in parts per billion, after all. However, it is already known that some of these pollutants are highly toxic, even in extremely small doses. As well, it is reasonable to assume that water contains other toxic products we are not even aware of. It may take 10, 15 or even 20 years to establish a product's toxicity in practice.

On the other hand, the quantity of contaminants we consume in water is negligible compared with the effects of airborne pollution, or of contaminants in the food we eat. From this point of view, the overall effect of installing a water treatment device on your health is minimal.

The discussion could go on endlessly. There is no easy answer to the question; it all depends on your individual perception of the problem.

In our opinion, however, installing a domestic water purifier could be considered in three cases:

1. if your drinking water tastes bad year round or for several months of the year;
2. if your water is drawn from a well or other private source where there is a risk of contamination;
3. if, for whatever reason, you doubt the purity of your municipal water supply and wish to protect yourself from even the slightest risk over the short and long term.

Pollutants

Before considering the capabilities and limitations of the various types of treatment devices available, we must take a closer look at various pollutants found in water.

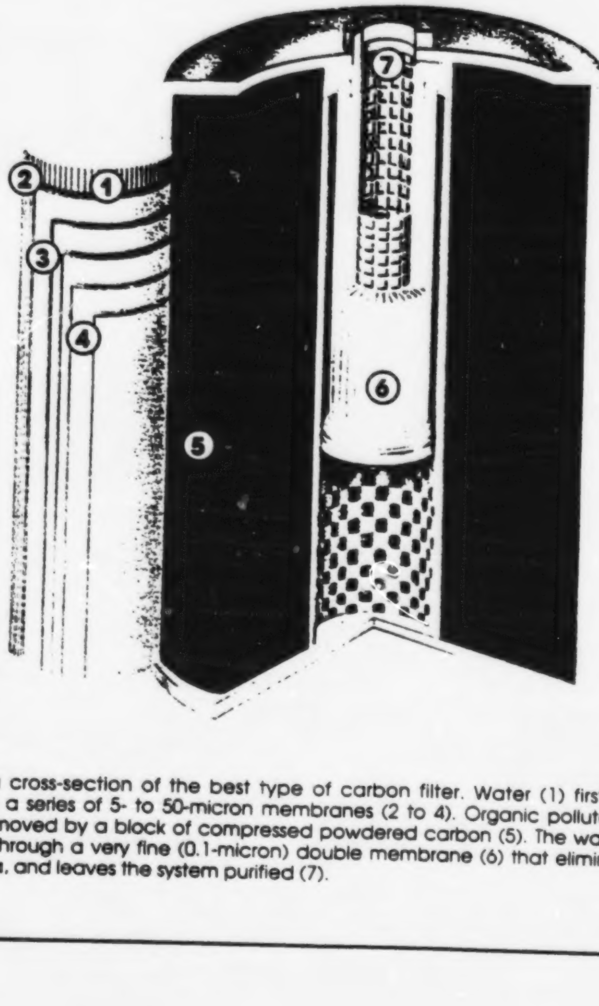
The foreign substances usually found in drinking water can be divided into four main categories: suspended solids, dissolved minerals, artificial organic substances and microbes. Many of the substances in all these groups are harmless to human beings, of course, although each group also includes highly toxic substances, or substances whose toxicity is unknown.

1. Suspended Solids

Water containing suspended solids, the simplest type of pollutants (grains of sand, twigs, algae, asbestos fibres and so on) is said to be turbid, or cloudy.

Turbidity is undoubtedly the easiest problem to solve because, aside from asbestos, the undesirable substances are quite large. Turbidity is rarely a problem in the water of large municipalities, as filtration plants can easily remove suspended solids.

Carbon Filter



This is a cross-section of the best type of carbon filter. Water (1) first passes through a series of 5- to 50-micron membranes (2 to 4). Organic pollutants are then removed by a block of compressed powdered carbon (5). The water then passes through a very fine (0.1-micron) double membrane (6) that eliminates all bacteria, and leaves the system purified (7).

Illustrations: Luc Mélivier

2. Dissolved Metals and Minerals

This group includes both minerals essential for life, such as potassium, and heavy toxic metals, such as cadmium. Minerals and metals may come from natural sources, e.g., soil rich in potassium or arsenic, or from artificial ones, e.g., chemical residues containing mercury or lead. The scientific name for these products is inorganic substances, which means they do not contain carbon.

Harmless minerals. Potassium, sodium, calcium and iron are all essential for life and are found in most municipal water supplies and in bottled spring water. Quantities vary according to the nature of the surrounding soil.

Whether they are removed from the water or left in it does not matter a great deal as far as nutrition is concerned. As we noted in an article on bottled water (October 1987), the food we eat often contains 10, 100 or even 500 times more of these minerals than water does.

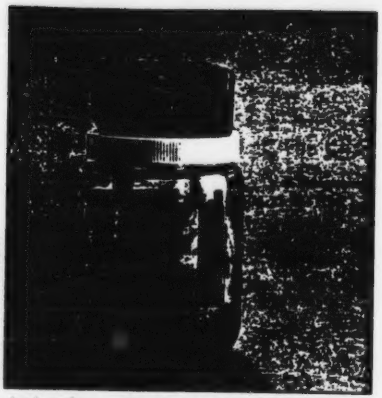
Purists, most frequently found among the vendors of water distillation devices, claim that such minerals are less readily absorbed by the body in inorganic form than when they come in food. They add that the minerals consumed in water, calcium in particular, can accumulate in the body and form harmful deposits. As far as they are concerned, all minerals in water are impurities.

Toxic metals or metals of unknown toxicity. Arsenic, mercury, lead and cadmium are all toxic. Some people feel that current standards are reasonable, while others would like to eliminate these substances completely.

Fluoride is one mineral of unknown toxicity that remains quite controversial. While some people stress that it helps prevent tooth decay, others want to eliminate municipal water fluoridation projects entirely.

3. Synthetic Organic Substances

Pesticides, herbicides, phenols, chlorine and PCBs are all well-known synthetic chemical products which can turn up in drinking water. These "modern" pollutants are unquestionably the most disturbing, because very little is known about them. Without highly sophisticated testing equipment, it is even hard to detect them. Aside from a few large plants that use ozone or activated carbon, water treatment plants were not designed to eliminate them.


Photos: Clément Morin

Just a few minutes in the salesperson's electrolysis machine will, apparently, show you just how much pollution your water contains. But ask for the experiment to be repeated using some of the saleperson's own super-purified, demineralized water — with a pinch of salt added. The resulting water will be just as distasteful-looking as before, since the "pollution" is really metal from the electrodes that has dissolved in the water.

If such organic substances are hard to detect, one reason is because they are found in minute quantities. Quantities of minerals in water are usually expressed in parts per million (ppm) or milligrams per litre (1 mg/L = 1 ppm). Concentrations of inorganic substances are expressed in parts per billion (ppb). In practice, a concentration of 1 ppb, for example, means that there is one thousandth of a milligram of the substance per litre. In most cases a healthy body can almost certainly deal with such amounts, but some substances, such as PCBs, accumulate in the body because it cannot eliminate them. Drinking a litre of water with just 1 ppb of PCBs in it means that the body is absorbing 1,720 billion molecules of PCBs.

We should also point out that it is now known that chlorine itself can become a source of pollution. Combined with vegetable matter, it can form trihalomethanes, a family of four known or suspected carcinogens. An example is chloroform. Most chlorinated water contains minute amounts of chloroform. For many people the presence of chlorine is a good enough reason to purify their water.

4. Microbes

This group mainly comprises microorganisms such as bacteria and viruses. Parasites are also included here, although biologically they fall into a different category. Of all sources of pollution, microbes are the best known and the ones which have the most immediate consequences. When people become ill from drinking water, it means that an unusual quantity of harmful microorganisms has entered the water system and the chlorine has failed to destroy them.

Obviously, not all microorganisms are harmful. A healthy organism can cope with most of them. However, some microbes are more resistant and can cause problems.

It should be noted here that the three types of microbes mentioned earlier are of different sizes.

Bacteria vary in size from 0.25 to 30 microns (a micron is one-thousandth of a millimetre). To cause health problems, a colony of bacteria must be fairly large.

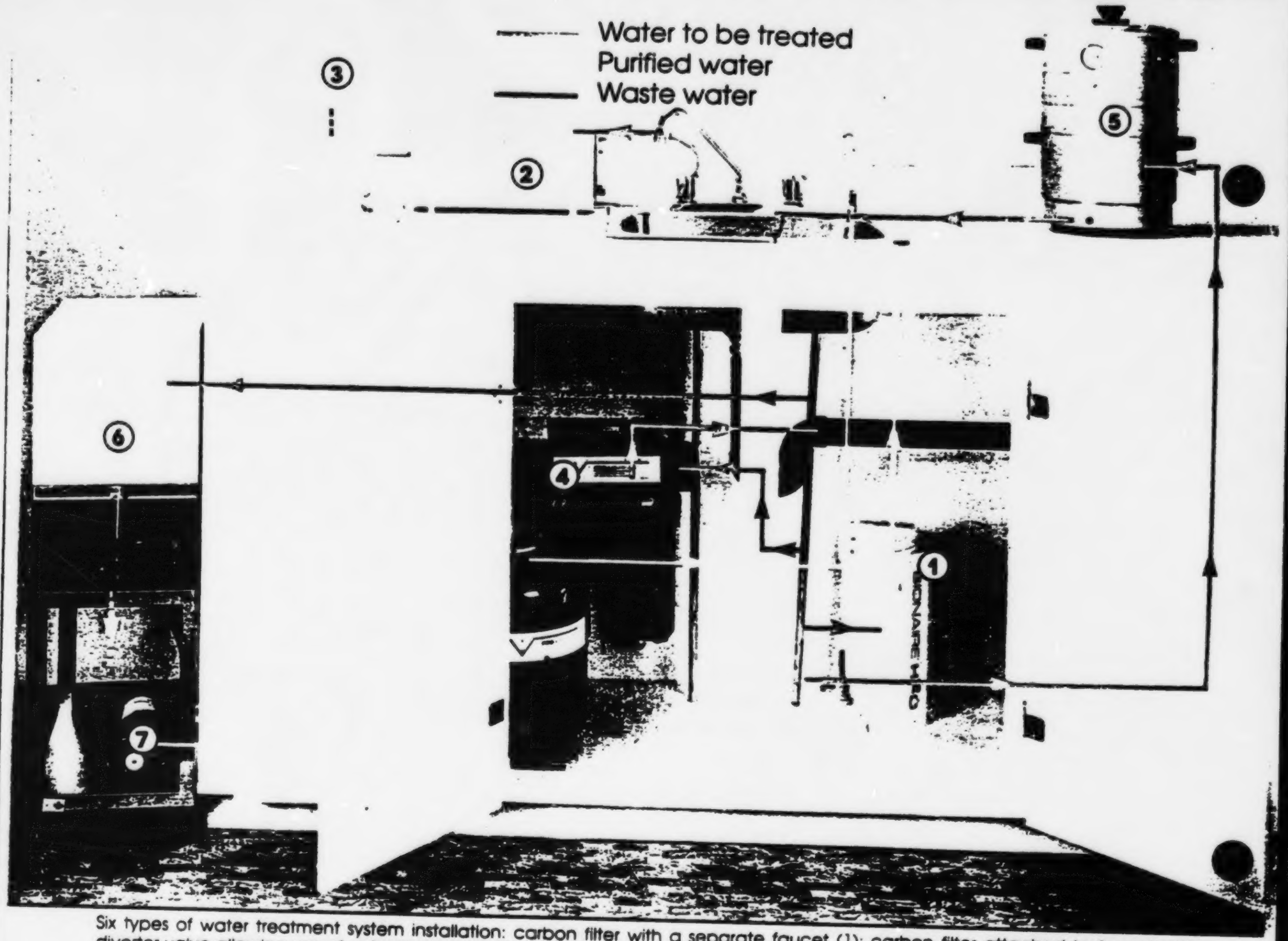
Viruses measure from 0.003 to 0.05 microns, and only the finest filters can trap them. They are often highly resistant, and a single virus can suffice to provoke an infection. Hepatitis and gastroenteritis are caused by viruses.

As for parasites, *Giardia lamblia*, for example, is a protozoan cyst which attacks the intestines. It is resistant to chlorine, but, like other parasites, is easy to filter. A five-micron filter is quite sufficient.

Cases of poisoning from impure water are fairly rare today, and usually have limited consequences. It is estimated that each of the three types of microbes described above causes roughly one-third of microbial contaminations carried by water, so eliminating bacteria alone is not sufficient.

Purification Processes

As we have seen, various categories of foreign substances are found in water, and all of them include some substances that are harmless, others that pose a health hazard, and others whose effects are largely unknown. For the purposes of water purification, however, such distinctions are rather academic, as treatment devices are unable to distinguish between toxic and non-toxic substances within a single category. They will usually eliminate all substances in the same group, or all substances of the same size.



Six types of water treatment system installation: carbon filter with a separate faucet (1); carbon filter attached to faucet with diverter valve allowing use of untreated water (2); filtering pitcher (3); reverse osmosis system with storage reservoir and drain (4); water-cooled distiller without auto-off (5); air-cooled distiller with separate faucet (6) or with pump (7) allowing continuous supply if system is installed in the basement or another room.

No single purification device can eliminate all contaminants; each type excels in a particular field. For this reason, many treatment systems employ more than one type of device.

Broadly speaking, there are two main types of household water treatment systems. Devices in the first group mechanically filter out undesirable particles but allow water to flow through. There are several kinds: traditional sediment filters, ceramic candle filters, reverse osmosis filters and other membranes, and activated carbon filters.

Devices in the second group use various chemical processes to neutralize pollutants and microbes, or to separate contaminants from the water. This group includes distillers, ultraviolet devices, ozonators, silver particle filters and ion-exchanging resin filters. Let's start with the first group.

Mechanical Filters

1. Sediment Filters

These simple filters, made of fibre, foam, sand and so on, are largely ineffective in removing microbes, dissolved minerals or organic substances, but are useful for removing suspended particles. They are often employed as prefilters to treat turbid water from wells and other private sources, and to prevent clogging in finer filters, thus considerably prolonging their life.

2. Ceramic Candle Filters

Ceramic filters usually come in the form of a hollow, candle-shaped tube; their texture resembles that of a traditional clay flower pot, although the pores are even smaller.

Ceramic filters are very straightforward and have been around for a long time. Water is simply forced through a ceramic barrier 1 or 2 cm thick. The pores of the ceramic are very fine (0.5 to 1 micron), and the filter can trap a wide array of impurities, parasites and most bacteria. However, they cannot filter out viruses and organic pollutants.

Ceramic filters are well suited to combatting bacterial contamination. Water flows through them rather slowly, however, and they tend to clog easily, even using municipally treated water. To clean them, you must brush the outside surface.

3. Activated Carbon Filters

Activated carbon is particularly suited to the removal of organic pollutants, such as insecticides, chemical wastes and PCBs, as well as chlorine. It does not remove microbes and dissolved minerals.

Each carbon granule is full of microscopic channels, which trap contaminants when water passes through them. Activated carbon gets its name from the treatment it undergoes to remove impurities and expose its pores.

The filtering properties of activated carbon depend on the carbon itself, i.e., the material used to make it, the quality of processing, and the mechanical design of the filter. For instance, the overall quantity of carbon must be sufficient to prevent premature saturation. Moreover, it is essential for the water to flow evenly throughout the carbon instead of passing directly through a limited number of channels, and for the flow rate to be sufficiently low to ensure adequate contact.

Activated carbon filters are manufactured in the form of granules, powder or compressed into solid blocks with some binding material. Activated carbon devices almost invariably use carbon cartridges that are replaced as needed.

4. Fine Membrane Filters

Synthetic membrane filters are a recent product of modern technology. They contain innumerable, carefully calibrated openings that, among the devices tested, were as small as 0.1 micron.

Filtering membranes are generally used in conjunction with other filters and are designed to eliminate bacteria. Generally, a 0.4 micron filter is sufficient to trap bacteria.

5. Reverse Osmosis

Reverse osmosis filters contain a semi-permeable membrane whose pores are so small (0.0005 micron) that they block almost all foreign bodies in the water, including microbes, dissolved minerals and organic substances. Only volatile gases or organic substances with low molecular weights such as chlorine derivatives pass through them.

Three types of reverse osmosis membranes are available. Cellulose acetate and cellulose triacetate membranes have a reputation for fragility, but today the best membranes are made of polyamide resin and known as thin film composite (TFC). Stronger, and more resistant to variations in acidity and temperature, they also have a better flow rate. Nonetheless, the flow rate remains low at about one litre per hour, so a reservoir tank is required. The flow is directly affected by the water pressure, and an average pressure of 40 pounds per square inch (psi) is considered a necessary minimum.

There is a constant water flow around a reverse-osmosis system, and at least 75 per cent of water entering must be drained off as waste. As well, TFC reverse osmosis membranes cannot tolerate the presence of chlorine, so a carbon pre-filter is essential. If the water supply is the least bit turbid, a sediment pre-filter is also needed. Finally, if the water is rich in iron or minerals, a full analysis is essential to determine what kind of pretreatment is required.

Reverse osmosis cartridges generally last about three years. Should the fragile membrane be punctured, however, you may not notice it immediately. To check the membrane's operation, manufacturers sell a small device which measures the electrical conductivity of the water and warns you when the concentration of foreign matter exceeds 20 or 50 ppm, depending on the model.

This type of filter performs best when used regularly, since if it is allowed to dry out, filtered minerals and contaminants may form a crust on the membrane and reduce the flow rate substantially. For this reason it is not a good idea to purchase a reverse osmosis system that produces a lot more water than you consume. The only way around this problem is to purchase a system with a relief valve, which will permit the system to keep running at a low level, when the tank is full, by draining out the purified water along with the waste.

Non-mechanical Treatment Devices

1. Distillers

Water can be distilled by simply bringing it to a boil, then condensing the escaping steam. In this way, all substances whose boiling point is higher than that of water can be eliminated, including minerals, heavy metals and most synthetic chemical pollutants. Distillers also eliminate all microbes.

However, a number of substances will boil at a lower temperature than water. Chloroform, for example, can escape in steam and be condensed with the distilled water. Some manufacturers have installed small vents to let such volatile substances escape, but their efficacy is dubious. The surest way to eliminate these substances is to use a carbon filter. For this reason, all of the distillers we tested are equipped with a carbon post-filter and, occasionally, a carbon pre-filter. This combination of purification methods enables one to obtain an extremely pure water.

Two distinct systems are used to condense steam. In the first type, the steam travels through a coil equipped with cooling vanes. A fan circulates air around the coil to accelerate heat exchange. This system is fairly noisy and produces quite a lot of heat in the house. Consequently, it is often advisable to install the distiller away from living areas. It can also be run at night.

The second type of distiller is water cooled and is more compact. However, to operate properly, such a device uses about three litres of cooling water for each litre of water it processes, and for this reason requires a drain.

2. Ultraviolet Light

Ultraviolet (UV) light kills microbes, and in ultraviolet water purifiers, the water simply flows past a lamp. Unlike chlorine, UV rays do not produce any by-products.

For UV devices to be effective, it is essential for the water to be clear, otherwise suspended solids may prevent the rays from reaching all microbes. For the same reason, the lamp must be kept clean, and replaced as the need arises. The device we tested had a photoelectric cell behind the water column to shut down the equipment when the luminosity became too weak.

UV devices do not provide complete protection against parasites, however, and a five micron pre-filter is highly recommended, if not essential.

3. Ozone

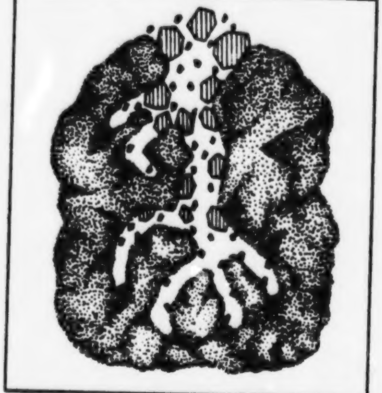
Ozone (O_3) is a gas obtained from oxygen (O_2) by passing a strong electric field or an ultraviolet wave through air, and it is the most powerful germicide available.

The Problem with Carbon

Activated carbon is recognized to be far and away the best and most economical means of removing a majority of chemical pollutants. It is not perfect, however.

Although the public may be unaware of it, the scientific community recognizes that carbon can itself be a source of contamination. We subjected all the carbon cartridges to a rigorous test to verify if any were releasing even minute quantities of polycyclic aromatic hydrocarbons. This is a family of 16 substances that are almost all byproducts of burning. They are known carcinogens. All our analyses were negative, however, so it appears that carbon manufacturers are ensuring that their product is properly cleaned with the necessary solvents.

Carbon's second drawback is the fact that it can be an excellent breeding ground for bacteria. Trapped in a dark and warm environment, some bacteria may feed on the organic materials filtered by the carbon and reproduce rapidly. If your carbon filter unit is inactive for just 24 hours, your first glass of water is likely to have more bacteria in it than untreated tap water. This is why the federal government attempted to ban the sale of carbon filters in 1981.



Impurities are trapped in the carbon's very fine pores.

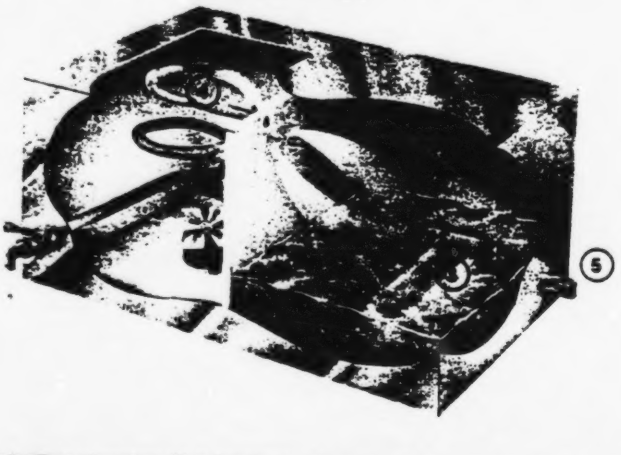
The industry responded rapidly. The industry did not question the fact that carbon can be a breeding ground for bacteria, it simply said that no cases of poisoning could be blamed on the use of carbon filtration, despite a 50-year history of use. Nonetheless, as a precautionary measure the industry adopted a series of voluntary guidelines. Carbon filters should only be used to filter water with a known bacteriological content, in others words, water that has already been treated. If water quality is not known, a preliminary analysis must be made and, if necessary, a disinfection device must be added at the output of the carbon filter. In all cases, the water should be allowed to run for 30 to 60 seconds after any period of disuse. This in itself will eliminate a good proportion of any accumulated bacteria.

Perhaps the most serious problem with carbon, however, is the fact that there is no way to know whether or not the filter has reached the end of its useful life. Only the reappearance of an unpleasant taste can really tell you whether a carbon cartridge should be replaced. Rather than wait for this to occur, you are probably best to follow the manufacturers' recommendations concerning cartridge replacement.

Ozone molecules react chemically with impurities in the water to destroy microbes, oxidize organic contaminants and, under certain circumstances, precipitate heavy metals. A carbon filter is usually installed at the outlet of the ozonator to eliminate such metals and contaminants.

Ozone released into the air in small quantities is not toxic. It is released after storms, and plants produce it constantly. Ozone is widely used by municipal water treatment facilities in Europe and now in Montreal.

Distiller



A distiller's boiling chamber (2) is first filled with water (1) (either manually or through a continuous supply). The electric element (3) brings the water to a boil and the resulting vapour travels into the condensing coil (4), which is cooled by a fan. The reservoir should be cleaned regularly and emptied through this drain (5).

4. Silver

When exposed long enough to silver, bacteria die. Silver particles are therefore sometimes employed in ceramic or carbon filters to provide or increase anti-microbial properties. Silver's effectiveness various greatly depending on the particular device it is used in. Silver may be considered either a bacteriostat, which inhibits the growth of bacteria, or a bactericide, which kills bacteria.

However, silver itself can be toxic. For this reason, it is essential that the particles not escape from the filter and contaminate the filtered water. The acceptable standard is 50 ppb of silver.

5. Ion-exchanging Resins

A filter using ion-exchanging resins softens water by eliminating calcium. Small resin pellets charged with sodium ions attract calcium and release sodium in the filtered water. Such devices are often used to soften household water. While hardness is not a form of water pollution, hard water can cause stains that are difficult to clean. Hard water does not have a pronounced taste, although it can affect the taste of juices, coffee and so on. It also leaves many people with dry skin.

6. Other Systems

In addition to the range of chemical devices discussed above, we should also mention automatic chlorinators and iodizers, which sterilize water by adding chlorine or iodine. They may be useful for a number of applications, but they are rarely employed and we did not evaluate them. Maintenance is complicated, and they must be installed by a professional.

Practical Considerations and Installation

To choose a water treatment system, it is not sufficient to look at the device's ability to filter contaminants. Practical considerations and ease of use are very important, as the devices will be used regularly.

There are several ways to install treatment devices. The most practical systems are those installed under a kitchen counter and connected directly to the water supply system. A branch pipe is run from the cold water pipe to the treatment device, and a second tap is installed near the sink. Untreated water can be used for dishes, washing and so on. To obtain drinking water, simply open the second tap. Some systems that operate in this fashion are placed on top of the counter and linked to the cold water faucet with an adapter and diverter valve. Evidently, they take up counter space.

With both types of installation, it is important for the flow rate to remain fairly high, otherwise the user will quickly tire of waiting to fill up a glass.

Counter-top models are very easy to install; the others will require a bit of skill, although a needle valve which operates and automatically seals the cold water pipe enables the user to install the device without soldering, and without calling a plumber.

Purification Principle	Effective against...	Drawbacks
Carbon (granulated, powder or block)	Bad taste Organic pollutants	Difficult to determine when carbon is saturated. Effectiveness extremely variable depending on design.
Membrane (0.45 to 0.1 micron)	Bacteria	Clogs rapidly without effective pre-filter.
Silver	Growth of bacteria	Possibility of excessive silver released in water. Long contact time required
Ceramic	Sediment Bacteria	Low flow rate. Clogs easily. Frequent cleaning required.
Ultraviolet light	Bacteria Viruses	Requires built-in safety system. Permanent installation.
Ozone and carbon	Sediment Bad taste Organic pollutants Bacteria Viruses	High price. Small quantities produced.
Reverse osmosis and carbon	Sediment Bad taste Organic pollutants Minerals Bacteria Viruses	High price. Effective pre-filter essential. Minimum water pressure of 40 psi required. Very low flow rate. Drain required. Three litres waste water for each litre purified.
Distillation and carbon	Sediment Bad taste Organic pollutants Minerals Bacteria	High price. Time-consuming and frequent cleaning necessary. Produces large amounts of heat. Air-cooled models noisy. Complex apparatus. Produces hot water. Very low flow rate. High energy consumption.

The Problems of Distillers

Distillers pose special installation problems. The first question you should ask yourself is whether you want a continuous feed system with a second tap, or whether you prefer to simply draw the water from the tank. If you choose the tap, you will have to buy an electric pump and a tap, which will add roughly $300 to the bill. In both instances, the distilled water will likely be warm. It must be bottled and chilled in the refrigerator.

Second, ask yourself whether you want a counter-top model or one installed elsewhere, where the heat produced by the distiller is less likely to be bothersome. If you consume small amounts of water, a water-cooled distiller is more compact. You can also store the distiller in a cupboard and take it out once a week; in 24 hours, it can produce about 30 L of distilled water, which can then be bottled. If the distiller is installed in another room, remember that water-cooled distillers require a drain. Water- and air-cooled distillers can be installed with or without a pump, which may necessitate additional pipes.

TEST

Water Treatment Put to the Test

Choose your water treatment device carefully; one in two of those we tested rated no better than "fair" or "poor".

by François Lemay

To judge the effectiveness of various water treatment systems as completely as possible, we purchased virtually every model available. Our selection included five distillers, five reverse osmosis systems, eight high-capacity carbon filter systems installed either on or under the kitchen counter, four ceramic candle filters (with or without carbon), two small carbon filter systems that attach directly to a tap, two filtering pitchers, one ozonator and one ultraviolet sterilization unit. Half of these systems are sold only through in-home demonstrations.

The 28 devices we tested all claim, to varying degrees, to eliminate chemical pollutants, microbes, or both. As well as examining practical considerations and operating costs, our test focused on how effectively the various devices can purify large quantities of heavily polluted water under difficult conditions.

We used the latest testing methods and after 4,000 separate analyses were in a position to accurately describe the performance of each device.

Carefully Prepared Pollution

To evaluate the effectiveness of our treatment devices at eliminating organic pollutants, we prepared large quantities of chemical "soup" in a 25,000 L tank. It contained 11 metals and 18 organic pollutants in doses of roughly 250 to 500 ppb, which is 10 to 100 times the quantities normally found in polluted water. If a manufacturer claimed that the filter had a capacity of 4,000 L, we pumped 4,000 L of our soup through it at the maximum rate allowed. As the test proceeded we analysed the results at 33 per cent, 66 per cent and 100 per cent of the advertised total capacity, or of the amount employed during the test.

In systems with very low flow rates (osmosis, distillers, ozonators and pitchers), only one verification was made.

In the nine models that employ silver to control bacteria, the release of silver particles was verified, and none of the devices exceeded the 50 ppb standard.

To evaluate the elimination of bacterial pollution, we also filtered concentrated mixtures containing two pathogenic bacteria, *Escherichia coli* and *Pseudomonas aureginosa*, several times through all of the devices. Concentrations were 100,000 to 200,000 bacteria per mL. The test was rigorous, and only the most effective filters made the grade. The distillers were not subject to this test, since their ability to sterilize water is not in doubt.

The Ratings

It is very difficult to compare the results of various tests in absolute figures. Each vendor of water treatment devices will present you with test results, but unless you know exactly how each test was carried out, it is very hard to make comparisons. Rather than provide absolute figures (of which there would be thousands), we shall use our standard rating system, which takes into account this multitude of factors.

How Much per Litre?

Tap water	"0¢"
Home treated water	1¢ to 10¢
Bottled water (20 L)	13¢
Spring water (20 L)	15¢
Spring water (4 L)	25¢
Cola	80¢
Milk	90¢
Frozen juice	$1.00
Beer	$3.65

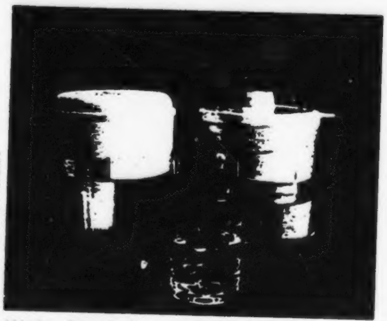
Essentially, with respect to **chemical pollutants**, a rating of **1** corresponds to an average elimination of at least 95 per cent of the pollutants, **2** corresponds to a minimum of 75 per cent, and **3** to 50 per cent. For the elimination of **minerals**, the ratings of carbon filters reflect the removal of toxic minerals only, while for distillers and reverse osmosis filters, total mineralization has been taken into account. A rating of 1 for the elimination of **bacteria** means the total absence of bacteria. Once again, to take into account the relative capacity of each type of filter, overall evaluation criteria are more rigorous for distillers and reverse osmosis filters, because the manufacturers of these devices claim that all bacteria will be eliminated. The ability to eliminate **viruses** is rarely evaluated using laboratory tests, since these are extremely complex. Our test was no exception, but ratings for viruses were added to the results table on the basis of recognized theoretical considerations. In this way, we were better able to make an assessment of the overall performance of each device.

One major proviso affects all our results, however. One must always distinguish between the quality of water immediately after treatment and the quality of water that actually reaches your glass after a waiting period. Water trapped in piping, and especially in the reservoirs of low-output systems such as reverse osmosis and distillation, can easily become recontaminated. To ensure optimum results, the water should be allowed to flow for several minutes after a period of disuse and poorly maintained systems should be disinfected.

Photo: Flora Ch

Filtering Pitchers

The **Water Boy** and **Brita** filtering pitchers are cheap ($20-$25), portable, easy to use, quite similar and fairly effective. Flow rates are low (it takes roughly three minutes to filter 1.25 L of water), consequently, the limited amount of carbon has the time to properly filter the water. They rated **3** against organic pollutants.



Photos: Clément Morin

Water Boy (left) and Brita pitchers

The granular carbon is mixed approximately half and half with an ion exchanging resin designed to soften the water. In water with average mineral content (125 ppm), we reduced hardness by 80 per cent. This is enough to make an appreciable difference to the taste of juices and other drinks. Unlike the resins used in domestic water softeners, these resins add no sodium to the water. They do add hydrogen, but this is harmless.

Effectiveness Against Bacteria

Neither of the filtering pitchers employ a fine membrane, nonetheless they both warranted a rating of **2** for their ability to remove bacteria. The carbon in them contains silver, and despite the heavy pollutant loads in the water we used, very few bacteria were found at the water outlet, even after 24 hours of stagnation at room temperature. Although a number of studies have cast doubt on the effectiveness of silver as an anti-bacterial agent, under the proper conditions, the results are noteworthy. To maintain the efficacy of the filtering pitchers, they must be kept as full as possible to allow the silver to work properly. While the manufacturers claim only that their products will stop the growth of bacteria, in some cases we noted the destruction of 200,000 bacteria per mL in a few minutes.

Under normal conditions, scarcely detectable amounts of silver are released by these pitchers. However, in acid water, we noted rates of between 10 and 15 ppb of silver; the maximum allowable is 50 ppb.

Both filtering pitchers do a good job, and do it equally well. Consumers who use only one or two litres of water a day will especially appreciate them. In practical terms, the **Water Boy** is slightly more compact and takes up less space in the refrigerator. The **Brita** is equipped with a meter which makes it easier to monitor the frequency of cartridge changes. The manufacturers state that a single cartridge has a capacity of 75 L, and recommend changing it monthly. At $7 per cartridge this adds up to $84 a year.

Economical and quite effective, filtering pitchers a a good choice for people who want to improve the taste of their water at a reasonable cost.

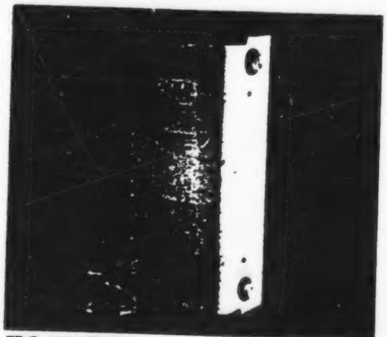
Filtering Pitchers

Brand	Brita	Water Boy
Price	$25	$20
Capacity (L)	1.75	1.25
Cartridge Cost	$7	$7
Replacement	monthly	monthly
Effective against...		
Hard water	1	1
Toxic metals	4	4
Organic pollutants	3	3
Bacteria	2	2
Viruses	4	4
Overall Rating	Good	Good

Ratings: **1**: Excellent **2**: Very Good **3**: Good **4**: Fair **5**: Poor

Ultraviolet Light System

Our tests confirmed that the **Trojan TS 507** ultraviolet light system will indeed sterilize water. Despite an extremely high flow rate of 25 L per minute, it was almost totally effective; all the bacteria were killed. The device comes with a system to measure the UV light intensity. This can be linked to a signal light, a flow counter and, most important, an automatic shutoff device in case of breakdown or power loss. It could easily complement any treatment system that is inadequate in killing bacteria, although you are highly recommended to use a five-micron sediment prefilter to ensure that the water is clear enough for the machine to work. It costs $600 and must be installed permanently, since its inlet and outlet pipes are of 3/4-inch diameter. To ensure effective long-term operation, the water must be clear and contain no more than 0.3 ppm of lead. The UV emission tube lasts one year and costs $35.



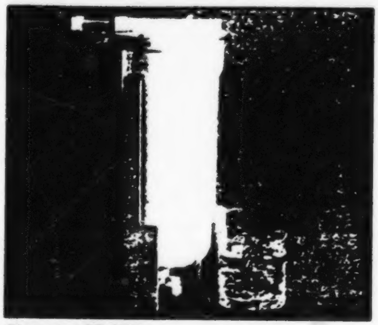
TROJAN TS-507 ultraviolet sterilizer

Carbon Filters

Ten of the treatment devices employ carbon, with membranes of varying porosity installed at the water inlet or outlet. Some also include silver particles. Our test clearly showed that the effectiveness of these systems in removing chemical pollutants is proportional to the quantity and quality of the carbon. Only large carbon filters compressed in a block succeeded in fully filtering contaminants throughout their useful life. The volume of contaminated water put through each filter was established according to manufacturers' claims, using a base annual consumption figure of 4,500 L, although this is undoubtedly higher than the actual consumption of a typical user. Given that the water treated was heavily polluted, this provided us with a comfortable safety margin. In only one instance were we unable to achieve the advertised capacity. The manufacturer of the **Apollo** unit claims that the device can process 45,000 L of water before it needs to be replaced. We obtained mediocre results with the filter after processing only 1,000 L, which proves that the claim is rather exaggerated.

The importance of using fine and properly compressed carbon is shown by the poor results obtained by the **NSA** granular carbon filter currently sold under the **BSI** label. It does indeed contain a lot of granulated carbon, but channeling occurred and the water was poorly filtered. This phenomenon can crop up at any time if the filter does not slow down the water flow.

To correctly interpret our results, it should be noted that even filters rated no higher than **4** should do a fairly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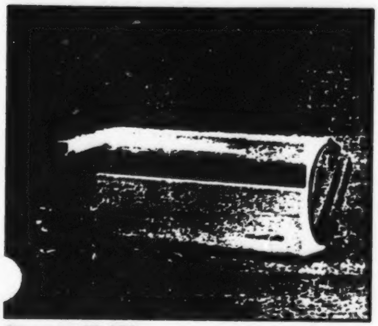
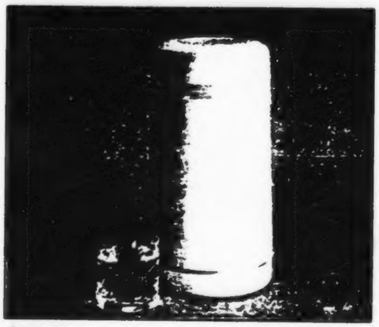
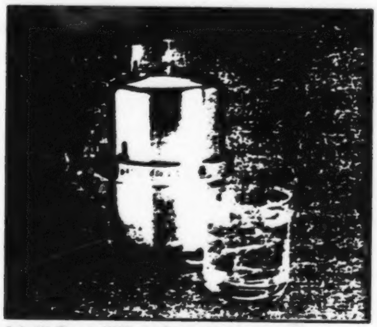
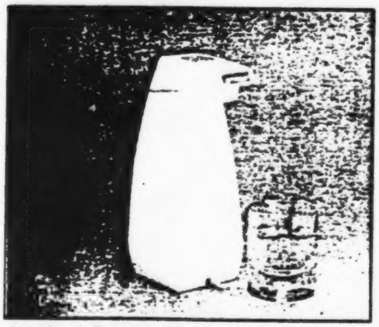
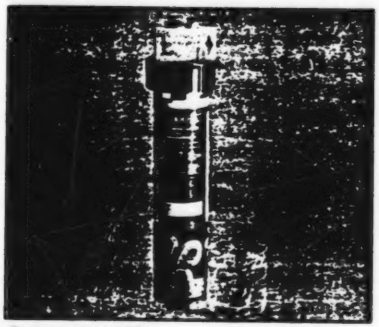
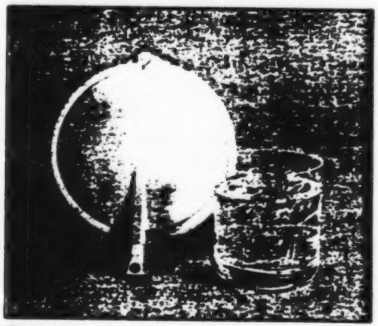

Bionaire BT-820


Amway


Multi-Pure 500 or Eco-l'eau-succès


Apollo or Bondel Ct-6A


Everpure H-100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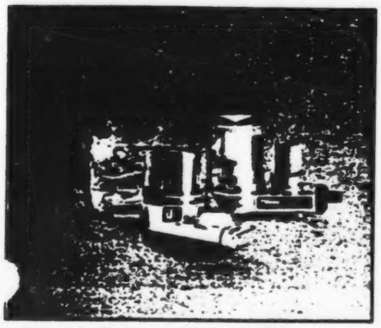
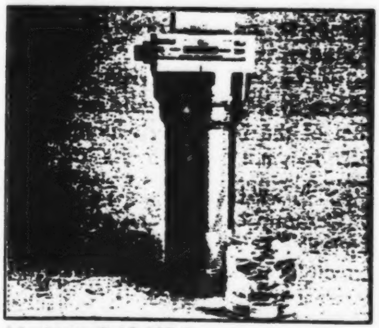

Instapure F2-U and Pollenex 99


Mastercraft 62-107-2

N.S.A. 100-C or B.S.I. B-120

good job of removing the taste of chlorine and odours from the water, but they will be unable to handle sudden, major contamination.

Effectiveness Against Bacteria

Only filters equipped with a very fine membrane managed to totally eliminate bacteria; the **Bionaire** model performed impeccably in this regard. It is the only filter in which each 0.1 micron membrane is individually tested and certified. Since it has a pre-filter of graduated porosity, which can be unrolled in layers, clogging posed no problems at all.

The **Filopur**, however, became clogged after processing only 400 L of water, because its 0.45 micron membrane is not adequately protected by an efficient pre-filter. Aside from the **Everpure** model, the other filters allowed one or other bacteria to pass too easily. When idle, the filters may provide a fertile breeding ground for bacteria, so the protection they provide is somewhat relative. Only the **Bionaire** model offered some protection from viruses, because its double membrane is electrostatically charged (one positive, one negative); under some circumstances, it can retain particles smaller than 0.01 micron.

Price and Installation

On the practical side, all these devices are easy to install and have a reasonable flow rate. Their cartridges are easy to change, except in the case of the **Amway**, which is hard to open. Their prices (including an installation kit and extra faucet, if required) vary greatly, as do cartridge prices. These differences are somewhat reduced, however, when performance and water production are taken into account. Eighty per cent of our rating is based on performance, and 20 per cent on ease of use and installation.

Overall this category of water purifiers performed quite poorly. Only the **Bionaire** rated *Very Good*, while the **Amway** and **Multi-Pure** or **Eco-l'eau-succès** rated *Good*. In our opinion, the other models are incapable of providing adequate protection unless one is certain in advance of the nature and quantity of pollutants to be eliminated.

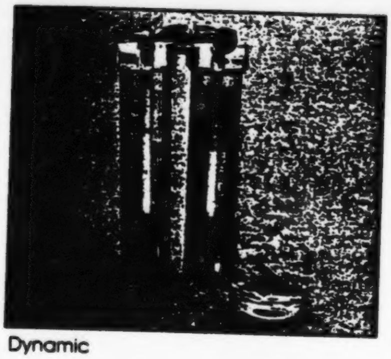
Ceramic Candles

Whatever their overall effectiveness, clogging occurred in all four of the ceramic candle filters we tested. We used only moderately turbid water (1.5 Ntu), but all of the devices became blocked well before they reached their rated maximum processing capacity. This is to be expected, but it means that, even with very clear water, the filter will have to be removed and brushed every three months or so if your average daily water consumption is about 10 L. Of course, as the filters clog up, the initially low but satisfactory flow rate will decrease.

Ceramic filters have a limited capacity for absorbing organic pollutants (and, therefore, the taste of chlorine) because there is little carbon in the middle of them. Only the **Dynamic** model performed well. It comprises two separate cartridges, one made of ceramic, the other of carbon. The **Katadyn** filter is unusual in that it does not contain any carbon, and is not designed to eliminate organic compounds. Incapable of removing chlorine, it is consequently of little use in improving the taste of water, although it performed best in removing bacteria, probably because of the silver salt crystals in its centre. The other filters allowed some bacteria to escape.

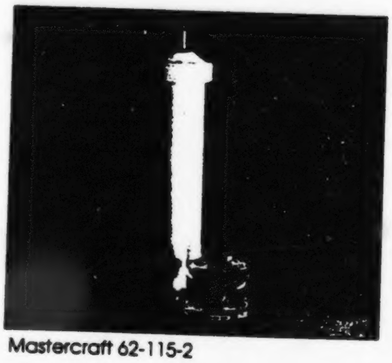
It should be stressed that sloppy cleaning can reduce the efficacy of ceramic candles in removing bacteria. If brushed carelessly, the filters can be cracked and the water outlet contaminated. The **Katadyn** filter can be installed horizontally and cleaned without removal, which is a definite advantage. Used with an effective carbon pre-filter, the **Katadyn** ceramic candle would certainly be an effective system, although its price would approach that of the **Bionaire**, which for its part does not suffer from a low flow rate and clogging.

Ceramic candles can easily last several years, since their lifespan is directly dependent on the wear caused by cleaning.

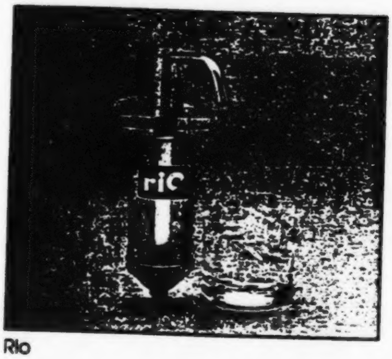


Dynamic

Katadyn HFSK



Mastercraft 62-115-2



Rio

Carbon and Ceramic Filters

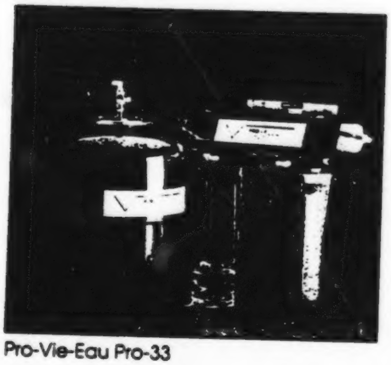
Description											Evaluation						
											Ease of Use		Effective against...				
Brand	Model	Sold through home demonstration	Installation	Type	Origin	Price *	Cartridge Price	Test Capacity (L)	Cartridge Replacement (months) ***	Annual Cost of Utilization	Maintenance	Flow Rate	Hard Water	Toxic Metals	Organic Pollutants	Bacteria	Viruses****
Carbon																	
						Very Good											
Bionaire	H20		O,U	Block/0.1 micron fine membrane	Canada	$400	$180	4,500	12	$180	1	2	5	3	1	1	4
						Good											
Amway		✓	O,U	Block	U.S.A.	$300	$85	4,500	12	$85	2	1	5	3	2	4	5
Multi-Pure/ Eco-l'eau-succès	500	✓	O,U	Block	U.S.A.	$550	$45	4,500	12	$45	1	1	5	5	3	4	5
						Fair											
Apollo/ Bondel	CT-6A	✓	U	Granulated/ silver	U.S.A.	$280	$280	4,500	60	$56	1	1	5	5	3	5	5
Everpure	H-100	✓	U	Powder/ 0.45 micron membrane	U.S.A.	$450	$75	4,500	12	$75	1	1	5	4	5	2	5
Filopur		✓	O	Powder/ 0.45 micron membrane	Switz.	$185	$25	300	1	$300	1	5	5	3	5	1	5
Instapure	F2-U		F	Granulated	U.S.A.	$27	$6	1,000	3	$24	1	2	5	5	3	5	5
Pollenex	Pure Water 99		F	Granulated	U.S.A.	$30	$6	1,000	3	$24	1	2	5	5	3	5	5
						Poor											
Mastercraft	62-107-2		U	Powder on felt	Canada	$56	$9	2,250	6	$18	1	1	5	5	5	5	5
N.S.A./ B.S.I.	100-C/B-120	✓	U	Granulated/ silver	Canada	$300	$300	10,800	36	$100	1	1	5	5	5	5	5
Ceramic																	
						Good											
Dynamic		✓	U	Granulated carbon/silver	Canada	$400	$100	1,500	12	$100	4	4	5	4	3	2	4
						Fair											
Katadyn**	HFSK		O	Silver crystals	Switz.	$380	$130	–	24	$65	4	4	5	5	5	1	3
Mastercraft	62-1015-2		O,U	Silver/ granulated carbon	Canada	$85	$32	3,000	24	$16	4	4	5	3	4	2	4
Rio			O	Silver/ granulated carbon	Brazil	$85	$15	350	3	$60	4	5	5	4	4	3	5

Ratings: 1: Excellent 2: Very Good 3: Good 4: Fair 5: Poor
O: on counter U: under counter F: at faucet
* Additional faucet or faucet adapter included.
** Tested only for bacteria; not designed to eliminate organic compounds.
*** According to manufacturer's recommendations.
**** Elimination of viruses not tested; figures based on theoretical considerations only.

Reverse Osmosis Systems

Prices of reverse osmosis systems vary enormously, from $130 to $1,800. The two cheapest models are portable, attach directly to a faucet, and have an independent reservoir. They do not turn off automatically, so you must watch out for spills. Luckily they do not have a high flow rate (about 9 L per day). Their performance could be improved, however.

The **Sears**, the only one without a carbon filter, allowed several types of organic contaminants to slip by. The **ChaR-0 2000** is the most effective model, but its membrane clogs easily because it does not have a pre-filter. Instead, the manufacturer has installed two carbon post-filters. A sediment pre-filter would undoubtedly have improved the test results substantially. Both these models caused us certain problems during the test due to pierced membranes or defective apparatus.


Pro-Vie-Eau Pro-33

Of the three remaining models, only the **Rainsoft** comes with a booster pump. To increase the flow, it pushes the water pressure up to 120 psi. This device may be the only possibility if your water pressure is low, but its output, even with its somewhat noisy booster pump, is lower than the other models. As well, although it performed very well, the other two were even better. Finally, its $1,800 price tag is simply prohibitive.

The **Pro-Vie-Eau** and **Just Water** systems produce water that is as pure as that produced by any distiller. Virtually no trace of minerals, microbes or organic pollutants can be found. Purists may rightly claim that the water produced is very slighty more mineralized than distilled water, especially as you approach the end of the membrane's useful life. Nonetheless, we don't consider this fact to be significant. The water produced is less acid and less flat-tasting than distilled water, since it has kept its dissolved oxygen. You will probably find it pleasant to drink which is not always the case with distilled water. These two machines are very similar, and both use a TFC membrane. The **Pro-Vie-Eau** also uses a pre-filter and a small magnetic water conditioner that temporarily reduces the hardness of the water and so prolongs the life of the membrane. Both machines eject 75 per cent of the water as waste (on a daily basis this is is as much water as is lost flushing the toilet three times).

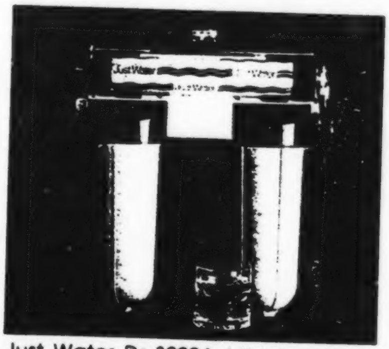
Upkeep

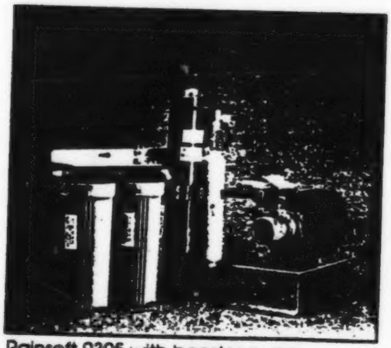
All of the filters warranted a rating of 1 for maintenance, since all that is needed is an occasional change of cartridge and a regular verification that the filter is not clogged or broken.

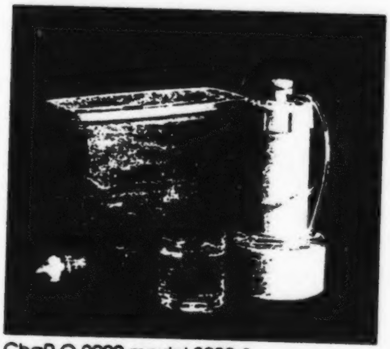
Costs

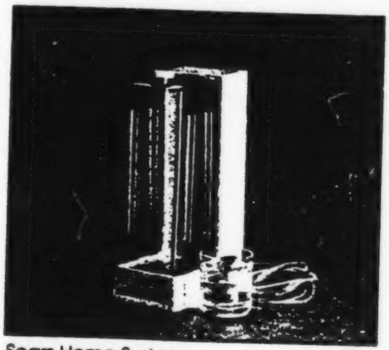
Carbon pre- and post-filters for all these models cost around $20; they must be replaced every year, or more frequently if the water is heavily chlorinated or very turbid. The reverse osmosis cartridges themselves are rather pricy at $250 to $325. If you wish to be certain that poor installation will not require a replacement membrane after just a year, **Pro-Vie-Eau** offers a total guarantee and home maintenance plan for $95 a year.

Remember that water filtered through a reverse osmosis system is at room temperature when it comes out of the tap. Moreover, while it is usually easy to install the device under the kitchen counter, space must also be found for the reservoir. Since the pressurized reservoir can easily propel water one floor up, it could be installed in the basement. If your water pressure is very low, however, whether all year round or seasonally, you should probably rule out a reverse osmosis system.


Just Water Ds-3000A (distributed by Titan)


Rainsoft 9395 with booster pump


ChaR O 2000 model 2000-S


Sears Home System

Reverse Osmosis Filters and Distillers

Description										Evaluation				
										Ease of Use		Effective against...		
Brand	Model	Origin	Type	Price	Cartridge Price	Annual Cost****	Auto off	Reservoir (L)	Production (L/day)	Noise	Maintenance	Minerals	Organic Pollutants	Microbes
Reverse Osmosis														
Excellent														
Just Water Titan*	Ds-3000 A	U.S.A.	Pressurized reservoir**	$825	$325	$150	✓	10	50	1	1	1	1	1
Pro-Vie-Eau*	Pro-33	Canada	Pressurized reservoir	$1,000	$275	$130	✓	12	40	1	1	1	1	1
Very Good														
Rainsoft*	9395	U.S.A.	Pressurized reservoir***	$1,800	$150	$90	✓	15	30	3	1	2	1	1
Good														
ChaR/O 2000*	2000-S	U.S.A.		$500	$250	$80		4	10	1	2	2	2	1
Poor														
Sears	Home System	U.S.A.		$130	$65	$65		4	9	1	1	2	4	1
Distillers														
Very Good														
C.W.A.	CWA1	Canada	Water cooled	$550	$15	$225		—	34	2	2	1	1	1
Dol-Fyn	A30 DEM2	Canada	Air cooled	$1,200	$15	$175	✓	18	33	4	3	1	1	1
Springtime*	12-3	U.S.A.	Air cooled	$1,350	$15	$200	✓	12	30	2	2	1	1	1
Good														
Durastill	803	U.S.A.	Air cooled	$1,425	$15	$210	✓	11	27	4	5	1	1	1
Pure Water	Midi D	U.S.A.	Air cooled	$1,350	$15	$225	✓	18	23	4	5	1	1	1

Ratings: **1:** Excellent **2:** Very Good **3:** Good **4:** Fair **5:** Poor

* Sold through home demonstration.

** With pump ($300, installation included) for continuous supply.

*** With booster pump.

**** Based on a daily production of 15 L, 5 ¢ a kw for distillers.

Distillers

The five distillers tested all rated 1 in terms of performance. Despite the heavy demands put on them, they eliminated virtually all contaminants, regardless of their nature.

However, carbon post-filters are essential to obtain these results. When we removed the carbon filters and analysed the resulting distilled water from each device, it contained several organic compounds. Some of the distillers even increased the concentration of certain volatile organic compounds.

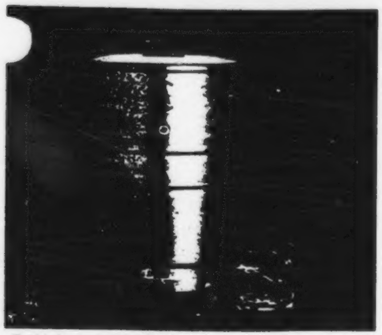
All of the distillers equipped with a good carbon post-filter are effective. The water produced is sterile, without chemical pollutants and almost completely demineralized (no more than 2 or 3 ppm of minerals remain). A great advantage of distillers is the fact that, if properly maintained, they will continue to work effectively year after year. The main differences between the distillers are related to ease of use and cost, since the differences found in the lab were insignificant.

Upkeep

With air-cooled distillers, minerals and other contaminants remain in the boiling chamber where they concentrate rapidly over time. If you distill 10 L of water a day, with the first reservoir of water containing 300 ppm of minerals, after a week a reservoir of water will contain 21,000 ppm. Evidently such minerals accumulate rapidly and, in the presence of heat, calcify on the chamber walls. How frequently they must be cleaned depends on the mineral content of the water.

The manufacturers of air-cooled distillers suggest a weekly cleaning. The process involves emptying and rinsing the boiling chamber, then filling it with a cleaning solution (commercial or vinegar). This should be left to soak for several hours, then drained and rinsed. If the device has not been cleaned often enough in the past you will have to let it soak longer or repeat the process. To get

continued page 61



C.W.A. model CWA1

rid of any leftover bad taste you will have to throw out the first 10 L of water distilled after cleaning and, given the low production of distillers, this will take half a day's operation. It will also be necessary to clean the distilled water reservoir occasionally.

Of the three air-cooled models, the **Dol-Fyn** is by far the easiest to clean, since its boiling chamber is removable and has a large lid. As well, its distilled water reservoir is also completely removable, while the other models have small lids that make cleaning more trouble.

A product does exist (polyphosphate crystals) that can be left in the boiling chamber to substantially reduce calcification, so that cleaning will be needed only every three or four weeks. Nonetheless, emptying the chamber once a week remains necessary, since too high a concentration of minerals can lead to foaming which in turn can result in the presence of contaminants in the distilled water. If you are prepared to pay the price ($125), an automatic emptying valve can be installed on all air-cooled models.

The two water-cooled models require cleaning three to four times less often because their boiling chamber is constantly rinsed by water. They have many fewer parts and are even easier to dismantle. They merit the best ratings for ease of cleaning. As well, water-cooled models do not have a fan and are much quieter (rating of **2**) than air-cooled distillers (rating of **4**).

Installation and Use

Some problems arise with regard to the installation and use of distillers. The devices have extremely low flow rates; they produce purified water drop by drop, which is stored in a tank. The purified water is warm or even quite hot. Four of the five models tested are equipped with an automatic feed system. A tube can be connected directly from the tap or the water pipe to fill the tank. Also bear in mind that distillers are fairly bulky.

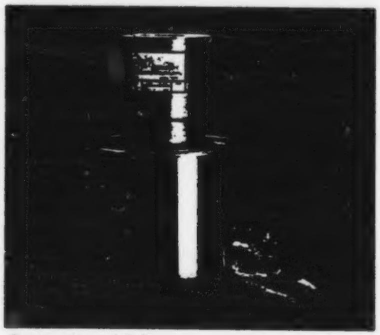
Operating Costs

The biggest drawback of distillers is their high electricity consumption. With a 1,500-watt heating element, a distiller costs 7.5 cents an hour to run. With an air-cooled machine, in winter 50 per cent of this cost is recuperated, since the heat given off contributes to heating your house. With water-cooled devices only 25 per cent of the electrical cost pays for itself as heat, since more heat is lost with the waste water. If you consume 15 L of water a day, distillers are easily the most expensive purifying devices. Depending on the model, electricity costs can vary from $175 to $250 a year.

Properly maintained, a distiller should normally last 15 years or more. At most a few parts — valves, heating elements, etc. — will have to be replaced, so after-sales service is important for the non do-it-your-selfer.

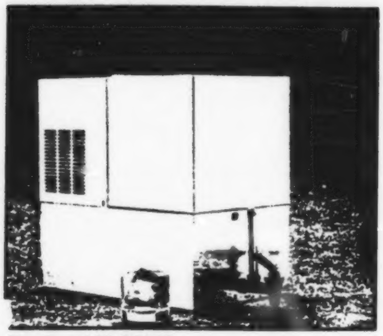
The Best Distillers

If you want to install the distiller in the kitchen, we recommend a water-cooled model. Both models tested are compact, fairly quiet and quite easy to clean. The **CWA** ($550) does not have a storage tank, so it is smaller. You will have to bottle the water, however, and remember to shut the device off when the container is full. The **Springtime** model has a 12-L tank and shuts itself off automatically when the tank is full. Both machines are fairly easy to maintain.

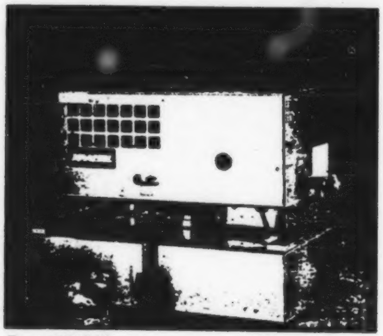


Springtime 12-3

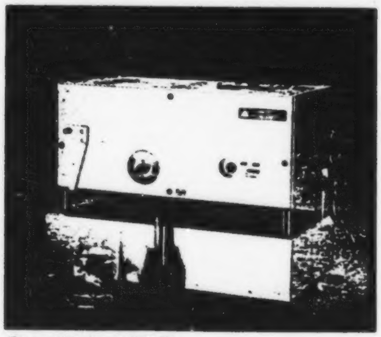
Air-cooled distillers tend to be bulkier. The **Dol-Fyn** model had the highest daily output, was the easiest to clean, and costs less at $850. Remember, you will have to purchase a pump ($300) if you want to install it in the basement or elsewhere outside the kitchen. The **Durastill 30H** and the **PureWater Midi-D** are American imports, cost more, and are more difficult to maintain.



Dol-Fyn A30 DEM2



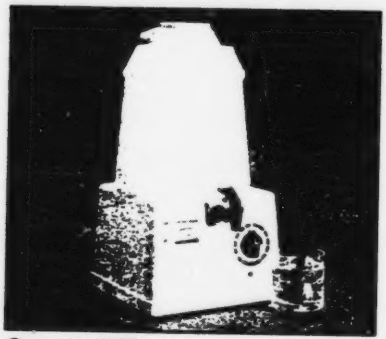
Durastill 803



Pure Water Midi D

Ozonators

To use the **Ozonator**, simply fill its 6-L tank, plug in the device, set the timer and 15 minutes later it will have generated sufficient ozone to sterilize the water and oxidize virtually all organic compounds. The device uses a carbon filter at the water outlet, which must be replaced once a year. Minerals, whether toxic or harmless are not affected by ozone, however. More troubling, even when oxidized some organic compounds can be toxic. The effectiveness of the device would no doubt be improved with a larger filter and finer carbon. Nonetheless, an ozonator is the cheapest water treatment system to use ($15 a year for the cartridge) and electricity consumption is minimal. Its portability also makes an ozonator a good choice if you must purify water at both country cottage and city home.



Ozonator 2000

Ozonator

Brand	Ozonator
Model	2000
Origin	Canada
Price	$650
Capacity (L)	6
Cartridge Cost	$15
Replacement	6 months
Effective against...	
Hard water	5
Toxic metals	4
Organic pollutants	2
Bacteria	1
Viruses	2
Overall Rating	Very Good

Ratings: 1: Excellent 2: Very Good 3: Good 4: Fair 5: Poor

A Few Tips

1. Let water run for about 30 seconds in the morning.
2. Avoid allowing water tanks to stagnate too long.
3. Use the lowest flow rate possible.
4. Regularly replace cartridges and make a note of the date.
5. Never allow a fresh-water distiller to become encrusted with scale.
6. Regularly check reverse osmosis membranes with the appropriate device.
7. Never filter hot water.
8. Always have well water or water from an unknown source analysed by a professional before installing a filter.
9. Respect warnings to boil your water or to cease consumption altogether.

Is Filtering Necessary?

Water treatment plants undoubtedly do a better job than some people claim, but is it reasonable to demand absolute purity for vast quantities of water, when we drink only one per cent? Nonetheless, if your water tastes terrible, it must be filtered.

The fear of pollution is another matter. To put things into perspective, it should be noted that even when the water you drink is pure as possible, only a small proportion of dangerous pollutants in the environment have been dealt with. Air, food and even bath water contribute more pollutants than drinking water does. Recent research has revealed that an individual absorbs six to 100 times more volatile organic compounds when showering than when drinking a glass of water, and the danger posed by chloroform due to chlorine in your water is 10,000 times less than the danger posed by cigarettes. A filtering device is not necessarily useful just because it is efficient. If you only drink one or two glasses of water a day at home, no filter will prolong your life expectancy.

The Sale... and Afterwards

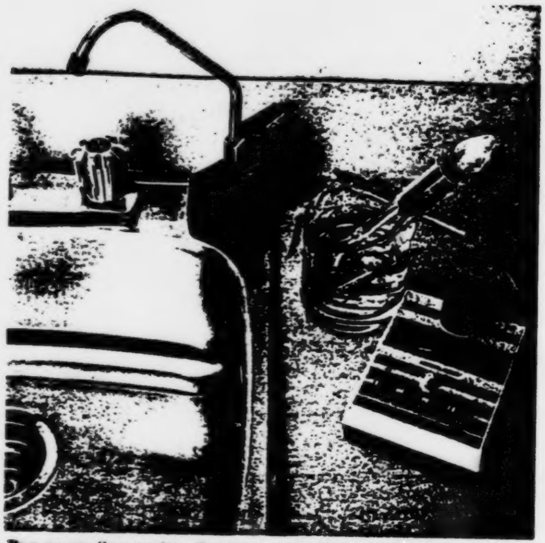
During our test, we heard the most absurd claims from salespeople, some of whom seem ready to provide an anti-cancer, anti-illness or anti-wrinkle guarantee in return for their commission. Before you sign anything, filter their comments and ask whether they belong to the Canadian Water Quality Association, whose members are expected to be well informed and who must comply with a code of ethics. They are not supposed to make doubtful analyses or demonstrations, as is often the case. Lastly, if you buy from a door-to-door salesperson, make sure that replacement parts will be available in three or four years.

All the devices we tested are guaranteed against manufacturing defects for periods ranging from one to five years. Performance is not guaranteed, however. In our opinion, the importance of the guarantee varies with the complexity of the device. An adequate guarantee is particularly important if you are purchasing a distiller or reverse osmosis device.

Choosing a Treatment Device

Despite the considerable diversity of water treatment devices, it should be fairly easy to choose one. A number of devices performed very well during our rigorous tests.

If you do not consume more than 2 or 3 L of water a day, filtering pitchers are ideal. For a few dollars you can improve the taste of the water without risk of contaminating it. The two filtering pitchers had the best quality/price ratios of all the products tested. The **Ozonator** also produces small quantities, but improves water even more. It sterilizes the water and neutralizes pollutants, but does not eliminate hardness or toxic metals. It costs $650 but its operating costs are very low. As it is portable, it is ideal for a secondary residence.


The purer the water, the less well will it conduct electricity. A conductivity meter, either separate ($150) or attached directly to a faucet ($125), or even a simple light bulb can measure this.

When household demands for drinking water are high, a high-capacity model will fill the bill. The **Bionaire** is undoubtedly the best, in both the on-the-counter (**BT-820**) and under-the-counter (**BT-850**) versions. It is fairly expensive, but no matter how you add it up, the cost per litre does not exceed four cents. Among the other models tested, the **Amway** and **Multi-Pure** or **Eco-l'eau-succès** are noteworthy; all of the others have serious drawbacks. After all, one does not purchase a water treatment system to improve the situation just a little; the aim is to protect against all known risks.

If you are disturbed by the minerals and the few viruses which may escape through a **Bionaire** filter, you will have to spend substantially more money on a distiller or a reverse osmosis system. While it may be difficult to justify the expense of such a sophisticated water treatment system, some people are prepared to do anything to protect themselves, even in the absence of a real danger. Since in the lab it was impossible to distinguish between the water produced by a good distiller and that from a reverse osmosis system, in our opinion ease of use must decide. In this respect, distillers cannot compete with reverse osmosis systems. Their performance may be a tiny bit better, but the noise, the heat they release to the room and in the treated water, the maintenance problems and the high cost in electricity remain major handicaps. The choice then becomes the two reverse osmosis systems that were rated "excellent". The choice between the **Pro-Vie-Eau** and **Just Water** models basically depends on after-sales service, since an improperly used membrane can easily become perforated after six months.

To conclude, remember the following: if you do not drink a lot of water, if you live in a big city with a good water treatment system, if you live in an area close to major pollution (refineries, etc.), if you smoke, if you eat highly only refined foods, if your house is very airtight, or if you do not normally take the trouble to maintain equipment that you use, buying a water filter will make no difference to the pollution dangers you face.

Our test results refer only to those products mentioned. General conclusions should not be drawn with regard to other products that are, or may eventually be, put on the market by the same manufacturer. The omission of a product, brand or model from our test should not be considered as a judgment, whether favourable or unfavourable, with regard to this product, brand or model. The use of our test results for advertising purposes is strictly forbidden.

Pollution Soup

This is the list of pollutants to which we subjected our water treatment devices. Concentrations varied from 250 et 500 parts per billion.

Inorganic	Organic
Arsenic	Chloroform
Cadmium	Benzene
Calcium	Carbon tetrachloride
Chrome	1,2 Dichloroethane
Iron	Trichloroethylene
Fluoride	1,11-Trichloroethane
Lead	Dichloroethane
Manganese	Tetrachloroethylene
Mercury	Toluene
Nickel	Xylene
Selenium	Ethylbenzene
Zinc	Lindane
	Phenol
	4,6-Dinitro-o-Cresol
	2,4-Dimethylphenol
	Pentachlorophenol
	4-chloro-3-methylphenol

Regulations

No matter what salespeople may claim, no water purification device is approved by any agency in Québec or Canada. The CSA approves the safety of electrical appliances, but does not certify their efficacy. At present, the only certification provided by the U.S. government comes from the Environmental Protection Agency and only covers the release of silver in water filters which contain the mineral.

Only the U. S. National Sanitation Foundation has a complete program to certify the performance of water purifying devices. In our view, the NSF's standards 42 and 53 are a good basis for judging performance. Very few devices available in Canada are evaluated according to these norms, however.

Jim FW Mackay

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Late Season 1988

Features

The Shape of the Canoe: Applying the Theory 13
John Winters concludes his three-part series on canoe design with a discussion of how the designer applies the lessons of the first two articles.

A Central Florida Primer 18
Lou Glaros takes us for a guided tour of the small streams in Central Florida. Wilderness canoeing a stone's throw from Disney World? You bet. Carol Casey adds some elegant black and white photos.

The Rebirth of a Canoe 28
The editor shows off a "new" E.M. White 15 foot Feather Weight that had been out of production for over 50 years.

Paddling Florida's Last Frontier 34
Dave Curtis, CSJ's regular equipment columnist, takes us for a cruise, in words and images, of South Florida's Everglades and the Mangrove Frontier.

The Drinks Are On Us 57
C.B. McCartan, a frequent contributor to Wilderness Camping in past years, comes back home with a meticulous, thorough look at water treatment, and an evaluation of three water filter systems.

Columns

Armchair Paddler 4
The View From Piety Hill 6
Racing 8
Camping 10
Backtalk 12
Sense 16
Solo Moves 24
Wildwater 26
Classics 29
Equipage 42
Solo Strokes 45
What's New? 47
Daytripper 66

Cover Photo

Photographer, columnist and feature writer Dave Curtis catches this paddler enjoying a solo canoe on the Wekiwa River in Central Florida. Sure doesn't look like urban congestion to us, Dave!

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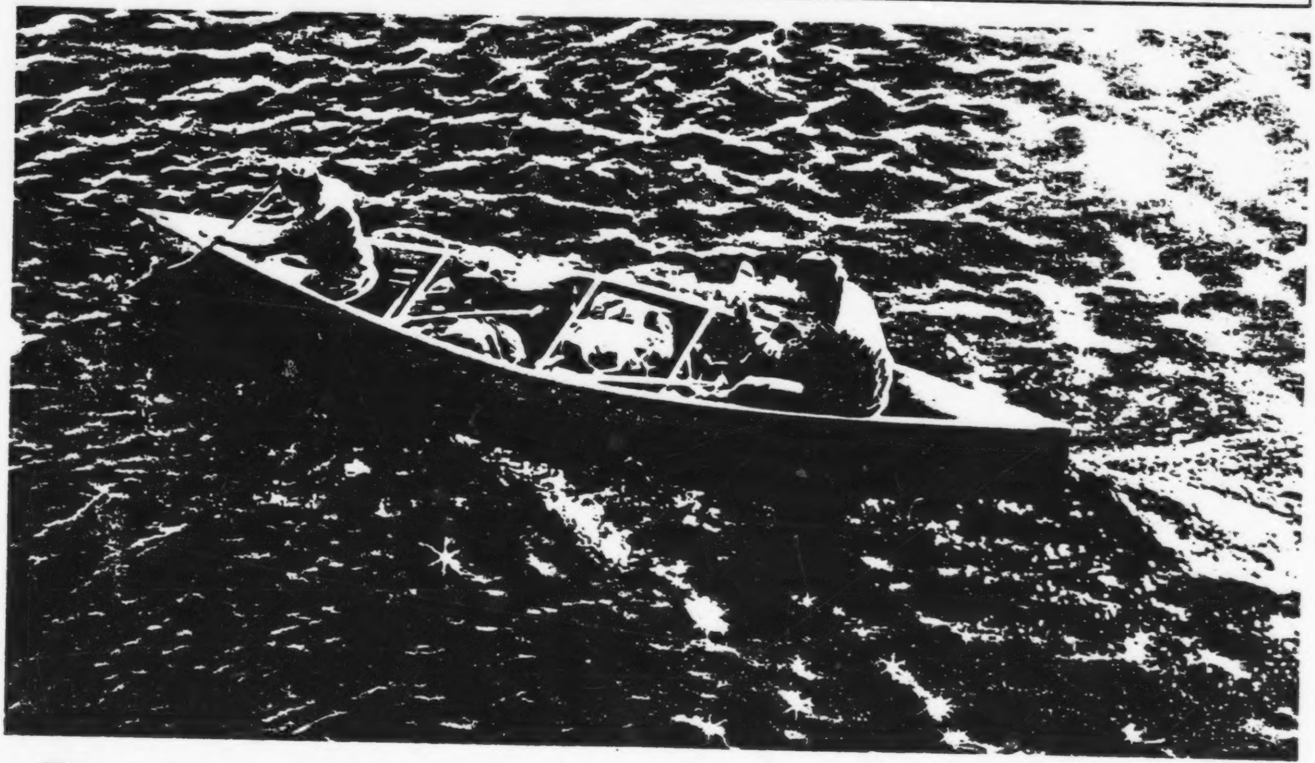
MAR 7 1989
ENVIRONMENTAL HEALTH SERVICES

C.B. McCartan

The Drinks Are On Us

Notes on Field Treatment of Water



Water is the most important constitutent of our lives. Our bodies are over 80 percent water; we need water for drinking, cooking, bathing, cleaning, and, of course, for floating our canoes.

This all too common substance has a very complex nature, really. In its frozen state it stores its energy; warmed, it rushes down mountainsides, cascading over edges and, though it is wonderful seen as a rapid, water scrapes and scours and reforms our landscape. It is nature's great abrasive. Its' unleashed fury wreaks havoc with manmade structures. The liquid strength of Mother Nature seems limitless. Yet in a placid pool or lake, it mirrors the hills and trees lining its shores. It is home to our fish. It cools our bodies, cleanses them; it satisfies our thirst. With a bit of uncommon gentleness, it assumes the shape of any vessel into which it is placed, but freeze it and it will escape its prison. Water covers most of our planet. Poor men come to it to satisfy their thirst; they know no other drink. Kings whose tankards are filled with choice wines, tiring of the grape, have knelt before it to drink. Water measures time. It marks the flow of history. It was Leonardo da Vinci who plunged his hand into a flowing stream and to his puzzled companion said, "See, my hand touches history; upstream the water is what is to come; below the water is what has gone before." Future and past, divided only by the sharp thin line of now.

How then, if water is so undeniably important to us — how then is it we have been so foul of manners as to pollute, to besmirch, our planet's limited resource, pure water!

We've taken it for granted — so much so that we may all live to see the day which future generations will call the "water famine".

We have long chuckled at

visitors to Mexico who have suffered the curse of Montezuma, the trots, *turistas;* whatever you call it, it is unpleasant. However, we who live north of the Rio Grande are rapidly being subjected to much of the same ailment. Mexico does not require its local governments to purify local water supplies. We in the United States to — or so it is alleged. We are protected by the EPA. Is anyone laughing? Actually, some of our water services in many ways are worse than those found in Mexico.

Our water sources in the United States are becoming increasingly dangerous to health. Heavy industry puts huge deposits of chemicals, all hazardous, back into the streams from which they take water for cooling towers. Farm states use vast amounts of herbicides, pesticides and fertilizers for crops; irrigation flushes these hard-core pollutants into our streams and underground aquifiers.

Some of the blame can be put on our innocent feathered friends. Birds wintering below the Rio Grande pick up amoebic cysts from water and seed food. Upon northward migration as far as northern Canda, they succeed in infecting water sources. Birds are notoriously undisciplined. None are potty trained. Their infamous droppings indeed do infect.

So where are we? *All water is suspect.* That cool, clear, bubbling stream may be far more dangerously contaminated than appearances would lead us to believe. Pollution need not be caused by careless humans. Animal wastes contribute to the problem. Winter kill can be a significant factor.

The quality of surface water is one of constant change. Minerals dissolve, causing sedimentation. Filtration by natural means is not always effective; biochemical decomposition of organic matter creates more problems. What is to be done? A friendly tip to the outdoorsman, for our canoeing friends: regardless of how tempting it may look, that lovely mountain stream flowing into the parth of your canoe may very well be enticing you into a gut-rumbling bout with some nasty gastrointestinal upset. In short, treat that water well, or certainly it will treat you ill.

So much has been written in recent years about Giardiasis, Beaver Fever, or what have you, that I do not intend to repeat all the old stock *obiter dicta* of the outdoors about yellow snow and running streams. A rehash here is unnecessary except to note that, if you know of the accident waiting to happen out there where Pepto Bismol may not be available, why not protect yourself and carry that which we hope will provide "safe water". An ounce of prevention, you know . . . .

Some Treatments Work, If . . .

Anyone who does not know by this time there is a decidely serious problem with our water in the great outback beyond the asphalt has for too long been content to bury his head in his sleeping bag. But what is to be done?

There are several methods, more or less efficacious in providing safer water. Boil it. Treat it chemically. Filter it. Treat it and filter it.

Boiling takes time and fuel. Chemical treatment takes more time, and results in foul tasting water. Filtering takes less time and is not always 100% effective. Some filters are better than others. Combine chemical treatment with subsequent filtration, and we tend to approach, after time and effort, a more controllable, acceptable potable water supply.

Like it or not, expend the effort and take the time, or else take your chances. It's a gamble, and you'll probably lose.

Boil It. We've all been given from time to time the pros and cons for boiling water as a step towards making it possibly somewhat safer to drink. Possibly . . . and somewhat.

A perfect example of the need for care is Isle Royale National Park in Lake Superior. A jewel of a park, a hiker's and canoeist's paradise. And a spider web of danger. All water — not some, but all — on Isle Royal is believed to be contaminated with the eggs of the tapeworm *Echinococcus Granulosus.* If the eggs of this nasty little beasty are ingested, they can grow inside your liver or lungs to form hydatid cysts. This tapeworm is common and is not just found on Isle Royale. It can be found anywhere there is a prey relationship among warm blooded mammals. On the island, there is a population of wolf and moose in a relatively small land mass. Those animals use the same water available to humans. To understand a cycle of the tapeworm, note it reaches the adult stage in the wolf. Eggs from the worm are passed with wolf feces, finding their way into water and onto vegetation. Moose feed in the water and ingest the eggs. If humans drink the water without adequate treatment they, too, ingest the viable eggs of the tapeworm. The eggs reproduce asexually and the larvae forms cysts in the lungs or liver. Wolves prey on the moose, ingest the cysts, and the cycle starts round two.

Chemical purification. Chemical treatment with chlorine or iodine does not destroy the eggs of this ill-mannered little beast. Boiling or filtering are the only ways to a (possibly) potable water supply. Great! But wood fires in the backcountry on the island are greatly discouraged. Boiling, thus, becomes a somewhat impractical solution. Besides all this, boiling water on a wood fire — if it were a suitable alternative — does have a side effect, the decidedly ill-tasting smokey taste imparted to the water. The only solution I've developed to make smokey water palatable is to treat the water with heavy doses of pineapple juice. Now — imagine paddling your canoe along the shores of Lake Superior and on Lake Richie with a 55-gallon drum of Dole's pineapple juice!

Further to provide sufficient water (a gallon per person per day is the safe rule) on a day-to-day basis requires a huge supply of fuel for the stoves. Who would volunteer to be the "waterboy" ("fuelboy")? on a canoe trip?

Chlorination. Believe it or not, it was just about 100 years ago that scientists began to learn that water, while necessary for our lives, was also playing a pernicious role in spreading disease. Treatment with sodium hypochlorite began during periods of epidemics. In 1904, the first serious effort was made to provide continuous chlorination of water supplies. Since that time, with the increasing use of chlorination, we have experienced an ever-decreasing incidence of water-caused epidemics.

Fine! So far so good. While the chlorine kills pathogenic organisms (thus lowering the risk of epidemics), it also reacts and oxidizes a wide variety of other impurities, particularly ammonia, iron, hydrogen sulfide, manganese, nitrites and organic compounds. Such reactions take place rapidly and must be completed before the chlorine is available for disinfection. Certainly then, in order that chlorine disinfection take place, the level of chlorine must exceed the actual need for disinfection. There must be residual chlorine present to do the job required. (Bear in mind, too much chlorine is harmful to health.)

Present standards for a safe supply of water are based on the absence or infrequent presence in low concentrations of coliform organisms. Sufficient sodium hypochlorite (Clorox, anyone?) must be added to the water to destroy the organisms. *E. Coli* is as resistant to disinfection as most enteric pathogenic bacteria. Coliforms are an excellent indicator of the possible presence of other dangerous bacteria because the coliform is easily detected, identified and isolated. But the fact that *E. Coli* are not present does not mean there are no other less easily recognized but dangerous organisms present.

There are enough variables to make chlorination alone a questionable method for purifying suspect water. The pH (index of acidity/alkalinity of the water) and the temperature of the water demand more or less chlorine addition and an increase or decrease in time exposure. Who carries a portable laboratory in the portage pack for all these necessary tests?

During the armed unpleasantness of the 40's, p-dichlorosulfamoyl benzoic acid (Halazone) was issued to the military. In the absence of heavy contamination, it made water potable, but its efficacy in treating cold and heavily polluted water (viruses and amoebic cysts) was questionable. Halazone (chlorine) in the recommended dosage depends on slow release of 2.8 to 3 parts per million of free chlorine for antimicrobial action. Chlorine under the best conditions (pH of 7 or lower, neutral or acidic water) and in the absence of nitrogenous compounds, hydrolyzes to hyposchlorous acid (HCo) an excellent germicide. However, HCo is highly reactive, and in the presence of nitrogen-containing amino and ammonia ions, it is quickly converted to the almost inactive monochloramine. Above pH 7 (alkaline water), HCo hydrolyzes to the less active hypochlorite.

These problems are solved in municipal water plants by providing enough chlorine to bond with the organic compounds and leave a biocidal residual of free chlorine. This involves continual testing. It is most impractical (yes, impossible) for the paddler out beyond the edge of nowhere. So, the paddler must resort to simple chlorination — adding a fixed dosage of chlorine compound to water of uncertain quality. Such a practice is unpredictable in its results and may be less than useless against bacteria and enteroviruses in the presence of organic material in the water.

Back to Halazone. It suffers from a low solubility, and a short shelf life of a few months stored at 80°F. Potency is reduced to 50% when stored at higher temperatures. Keep it in the glove compartment of your car and you might as well discard it. Exposed to air for two days and the tablets become almost useless. Once the bottle is opened the downward spiral of usefullness begins. Like making scrambled eggs without cracking the eggs, how can you use Halazone tablets without opening the bottle. There are far too many "hell if you do's and hell if you don't".

Iodine. During those peaceful years of boyhood, I often saw the skull and crossbones on the tincture of iodine bottle in the family medicine cabinet. Used to disinfect (and to sting like hell) iodine served to take care of cuts and scrapes so common among growing boys. Then I heard something that took a lot of getting used to: iodine was to be used to disinfect water!

Iodione imparts a horrible taste to water, and pineapple juice doesn't help one bit. Yet, when we realize that the clearn, flowing, cold stream can provide us with a serious case of salmonella, infections of all sorts, amoebic dysentery, giardiasis, hepatitis — well, then, reach for skull and crossbones.

Tincture of iodine from the old medicine chest can be used, if used properly, drop by drop.

Iodination is more effective than chlorination in disinfection of water. A weak aqueous solution of [illegible] ppm of iodine (I_2) at 77°F in 15 minutes or less will destroy amoeba and their cysts, bacteria and spores, algae and enteroviruses. (Take the full 15 minutes.) At 37.5°F. (near freezing), disinfection would take 20 to 30 minutes at the same level of concentration. Effectiveness is roughly directly proportional to temperature — colder takes longer. Elemental iodine does not react readily with amino and ammonia ions; thus it remains effective as a disinfectant in water contaminated with nitrogenous wastes. Iodine is effective over a wide pH range. At pH 6 it converts to hydroiodous acid, a more potent virucide than simple iodine (I_2).

How to use iodine, you ask? There are three acceptable methods. (1) Add 8 drops of 2% [illegible] of iodine to a quart of water. The result will be water of low palatability to counter its increased potability. (That translates

Table I

The amount of iodine going into solution depends on the temperature of the water. Quantities of nearly saturated iodine solution should yield an iodine concentration of 4 ppm per 1 liter of water.

Temperature, °F	Volume, cc	Concentration, ppm	Capfuls*
37°	20	200	8
70°	13	300	5-6
75°	12.5	320	5
100°	10	400	4

** Assume the cap from the 1-ounce bottle has a volume of 2.5cc.*

into an irreverent "safe to drink but tastes like hell".) (2) A[redacted] (if you can still find the stuff) t[redacted] The tablet releases active iodine to a concentration of 8 ppm. Globaline tablets, as with Halazone, lose their potency very quickly after exposure to air. (What's a guy to do?) (3) Use crystals of elemental iodine.

There is available at many sporting goods stores an iodine disinfectant kit comprised of a 1-ounce clear glass bottle, a hard plastic cap and 4 to 8 grams of USP-grade sublimed iodine — the iodine crystals in (3) above.

(**NOTE:** Iodine in large quantities is a poison. Those persons with thyroid problems must consult their personal physicians before using iodine to disinfect water.)

Fill the bottle with water, cap it, shake it for about 60 seconds. This causes some of the iodine crystals to dissolve. The amount of dissolved iodine depends on the temperature of the water. Use the saturated iodine solution (**NOT THE CRYSTALS**) to disinfect the water. Hold the bottle upright to allow the crystals to settle out. The bottle holds about 30 cc's. The cap can be used to measure out the correct amount. Pour the capful of solution into the water to be treated, wait for the disinfection to take place. (Take your time. Allow the iodine to work. See Table I.) To effect better palatability of the treated water, use less iodine and wait longer. The water will taste better — a wee bit better — and the iodine will have done its work.

In summary, then: the chemical treatment of water with chlorination, as usually practiced, is unreliable. [redacted]ther hand, v[redacted] including the enteroviruses, most resistant to disinfection. Iodination is m[redacted] the presence of nitrogenous wastes. Iodine has a longer shelf life than does chorine tablets. The shelf life of crystalline iodine is almost unlimited.

Filters

We have boiled, treated chemically, and worried if we've done enough. Is our water safe? Not necessarily.

How about filtration? Filters have recently entered the arena of the water purification battle. There are several on the market — some are good, some are fair, some are relatively ineffective. There are "drip filters" which are more like Joe DiMaggio's "Mr. Coffee" units than effective filtration devices. They may be effective; again, they may not. In most cases, they are small devices, providing little output of potable water and are marginally effective. Some filters are used much like a soda straw. I've never used one in that fashion, but my first impulse, my gut feeling, is that the size of the filter and the resident time in the filter (straw) is so short I must question the usefulness of the gadget. It just won't "zap" those pesky little critters.

Other filters are "force types" — pumps. They are more appropriate to the job at hand, so long as the filtering matrix bars passage of those dangerous pathogens.

The effectiveness of mechanical filtration depends on the balance between filter area, the size of the pores of the matrix and the velocity of water passing through those pores. Another consideration, and a very important one, is what does the filter do with the collected dirt? The filter matrix up continuously as the pores are blocked by collected dirt. (The user will readily notice the difference in pressure between the inlet and outlet faces of the filter.)

Another requirement of the filter-type device is taste and odor removal. Chlorine added chemically will ruin the aroma and taste of coffee around the campfire. Taste and odor removal are accomplished in a good filter by adsorption — attraction of the offensive taste/odor molecules to the surface of the adsorptive material. This material must be exposed directly to the raw water being filtered. Activated carbon is often used for the purpose of collecting taste molecules. The surface area exposed determines the capacity of adsorption. In this case, more is better. (In the straw-type "filter", less is worse.)

What should we look for in a water purifying device? While the cheapest filters probably are inadequate, it does not of necessity follow that the most expensive is the best. Price alone is not valid criterion.

The EPA (God bless their little hearts) defines "purify" as "rendering safe from harmful bacteria in the absence of specific statements indicating something else". Howszat? Come again! 'Twas brillig in the borogrove and the momrath outgabe?'

Many products being touted (and sadly, sold) as purifiers or purification devices that do not do their purported job. Many that have so claimed have been forced to alter their claims from "purifiers" to "water processor" or "treatment system" or "naturalizer".

Our friends on the Potomac are certain to keep muddying the waters. They seem unable to carry out their own mandates. They have no authority to enforce interpretation of the word "purifier" against products that make no claims about bacteria. Confusion reigns! Some non-purifying products have a variant of "pure" incorporated into their brand or company name. This is misleading — and the EPA does an excellent *pas de bourree* mincing through their running political ballet steps, and all for naught, water-wise.

Where does th[redacted]begin and end its jurisdiction? It is co[redacted] The former generally remove harmful bacteria; the latter rely on a chemical reaction over a period of time. There is ju[redacted] over the [redacted] of [redacted]. Bear in mind that pesticides are registered by the EPA — whether or not they actually purify. Devices must also meet Federal standards to be called purifiers, but they need not be registered. Confusing? To quote that eminent economic writer/reporter, Louis Rukeyser, ". . . Washington's ability to think sensibly about our . . . future would have to quadruple to become infinitesimal."

It appears that only the microstraining device (filter) can meet Federal standards — whatever they are!

To my knowledge — and I stand ready to be corrected if need be — [redacted] chemicals have been registered as "[redacted]" by the EPA. Some have been registered as "[redacted]".

So, We Select A Filter

Literature accompanying various filters indicate they can remove particles the size of a Giardia cyst (or smaller), and thus *may* provide safe drinking water. Such devices, if selected with care and are proven to be effective, might prevent giardiasis or other ailments in international travelers, backpackers, campers and canoeists anywhere the water may be of questionable quality.

The unfortunate fact is that there is only limited information available for successful evaluation of the efficiency of these filters. You must depend upon the written reports of laboratories *hired by* the filter manufacturers. Sometimes what is known as "vested interests" gets in the way. A wise old man once said, "He who pays the fiddler calls the tune." But judicious use of common sense can till be depended upon. In selecting a filter, consider the filter media (the ceramic or structured matrix or other material) through which the water passes. Those filters which rely on [redacted]. They just don't [redacted] of micro-organisms. Their principal use is to [redacted] (remove) [redacted] and [redacted] rust and such.

Ideally, a water purifier purifies instantly. Chemical treating mandates a a holding time. Various pollutants in the water can have adverse effects on the efficacy of the chemical used. Iron, sulfur and other common contaminants may "use up" all the chlorine, making it unavailable for destroying bacteria. But physically removing the harmful bacteria by microstraining provides instantaneous purification.

Color, taste and odor are common complaints levelled against water. [redacted] are sometimes used [redacted], but there are drawbacks. Such filters [redacted] growth. Such charcoal filters also [redacted].)

Equipment intended to purify water must be dependable, no ifs, ands or buts. It must be maintained with relative ease. An important feature that must be built into every filter is a strong indication that its useful life is nearing an end. Nothing lasts a lifetime. Keep that in mind when filtering your water. Keep that in mind when filtering your water. Keep a record of the number of pints or quarts passed through the filter matrix. This is a pain in the neck, but essential.

To summarize, a water purifying device must:

1. Remove harmful bacteria, purifying instantly.
2. Remove larger amoebic cysts, protozoan parasitic organisms, such as are not killed by chemical means.
3. Remove organic chemical pollutants, as well as bad color, taste and odor.
4. Remove chlorine and chlorine hydrocarbons.
5. Remove asbestos fibers.
6. Not support growth and release of bacteria.
7. Remove no dissolved minerals essential to good health.
8. Remove moderate amounts of iron and hydrogen sulfide.
9. Be compact, simple to use, be well constructed and require little maintenace; what maintenance is required should be easily done.
10. Sound the alarm when its useful life is ending.

Let's look more closely at the pump-type water purifiers since it appears this is the "way to go" — a remark not meant in any way to denigrate other types of filters which may be effective in performing the task for which they were designed. But that task isn't providing potable water in the dicey world of the outback.

We will not get into the area of "reverse osmosis" for the simple reason that such pieces of apparatus approach industrial size and are not of interest to one who carries his or her gear in the outback. For general information, however, such units are effective in removing dissolved salts, and such from water. Sea water can be made potable by reverse osmosis. Adversely, the bulky module must be replaced periodically, and that is a very expensive job. No free lunch there.

Distillation units seem to have the same advantages, but on the reverse side of the coin, distillation removes minerals essential to good health and taste. Such units use great amounts of energy for so low an output.

See Table II below for the pros and cons of various methods for treating water.

Reviewing the Filters

Let's look in depth at the Timberline Filter, the First Need® Purifier, and the Katadyn Pocket Filter — listed in no particular order.

Although there may be other pump-type filters available, we have not been able to locate them. We have thoroughly checked three models, all of which seem to have met with acceptance by outdoors people, and are generally available. Public acceptance, then, can be used as one parameter for our review. If the public won't buy, the filter will soon find repose on the ash heap of industrial error, like the Edsel. But, obversely, the fact the public does buy is no evidence of true worth. Remember the edict of Phineas T. Barnum . . .

Generally, water purifying devices make mention of the small micron size of their matrix. It is necessary to bear in mind there is a *nominal* and an *absolute* value that must be considered. For example, General Ecology claims their First Need® purifier removes small contaminates to a nominal rating of 0.1 micron (0.4 absolute). That is much smaller than the human eye can see. It means that nothing larger than 0.4 micron will pass the 0.1 micron opening. Confusing? How can a quarter pass through a hole the size of a dime? Well, it can't, because coins are rigid. But those dastardly little critters lurking in the water are not rigid. They are more like a blob of gelatine, and we all know that gelatine can deform and pass through an aperture smaller than itself. Ever see a tiny field mouse squeeze under a tight-fitting door? (See diagram relating to micron size, Figure 1.)

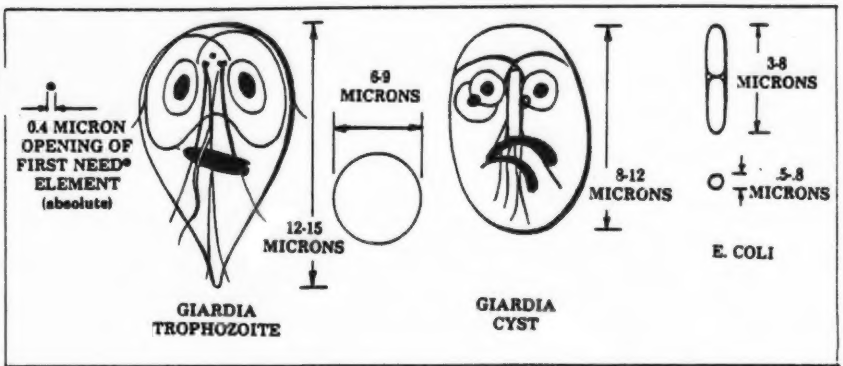

0.4 MICRON
OPENING OF
FIRST NEED®
ELEMENT
(absolute)
12-15
MICRONS
6-9
MICRONS
8-12
MICRONS
3-8
MICRONS
.5-.8
MICRONS
E. COLI
GIARDIA
TROPHOZOITE
GIARDIA
CYST

Figure 1
Relative Size of Giardia and E. Coli
Compared to Microstrainer

Table II

Method of Purification	Advantages	Disadvantages
Chlorination and Iodination	Good output; high flow; destroys bacteria	Can add halogen compounds to water through chemical reactions; do not remove chemicals, dirt, asbestos; contributes to bad taste and odor; chlorine and iodine should be removed by filtration water is consumed.
harcoal filters	Inexpensive; does help to [redacted]dors.	Such types can contribute to bacterial growth. They may remove symptoms of contamination without removing the contaminations.
Bacteriostatic chemical filters (must be EPA approved)	These units suppress bacterial growth within charcoal and activated carbon.	Do not purify against bacteria or cysts. Same disadvantages as charcoal filter regarding chemicals. [redacted]and other fine particulates. Bacteriostatic units are not intended to purify — [redacted] in filtration material. Ineffective against viruses, cysts, etc. No way to check when static effectiveness is depleted.
Microstraining filters	Generally considered [redacted]athogenic bacteria removed; cysts, chemicals, bad taste, odors. Depending on absolute rating of retention and whether there are any components present to absorb chemicals, including tastes and odors. For example, 30 microns screen is regarded as microstraining but cannot remove bacteria, tastes, odors; Ceramic filters alone **do not** remove organic chemicals, etc. but they can be called "microstrainers".	When flow rate decreases the unit cartridge must be replaced. Capacity to remove hydrogen sulfide is limited. Nitrates are not removed, which might be a problem in some areas of country.

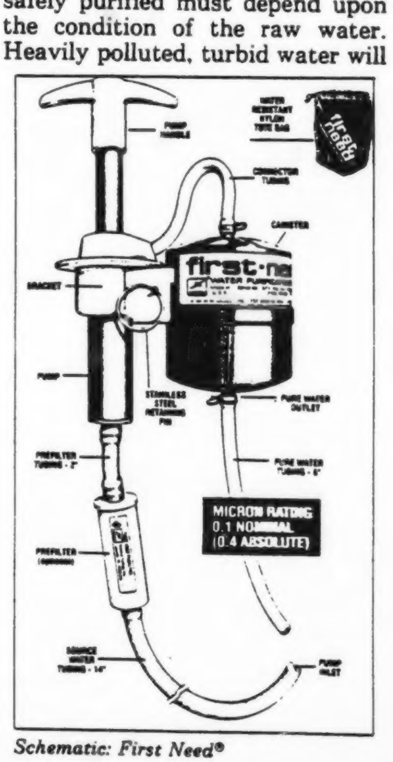
First Need® Purifier. One of the earliest domestic-made filters to prove effective in water purification was General Ecology's First Need® Portable Purifier. The purifier's unique "structured matrix" works in a three-fold manner: microstraining, adsorption and ionic charges.

By microstraining, the filter removes water-borne organisms and other particles with its [redacted] (nominal) (0.4 absolute). This physical retention (barrier) to living organisms makes unnecessary the addition of chemicals, Halazone, iodine or other pesticides, e.g., silver.

The high adsorption capability of the unit results in removal of herbicides, persticides, synthetic organic chemicals and, of course, chlorine and/or iodine when such are first added for the sometimes-used "chemical kill" step.

By providing opposite ionic charges, the unit removes colloids and ultra-small particles, binding them to the matrix without endangering the "pass-through" purified water. This adds protection above and beyond microstraining.

The unit will safely purify about 800 pints of water. As with other devices, the number of pints safely purified must depend upon the condition of the raw water. Heavily polluted, turbid water will


PUMP HANDLE
WATER RESISTANT NYLON TOTE BAG
first need
CONNECTOR TUBING
CANISTER
first·ne
WATER PURIFIER
BRACKET
PUMP
STAINLESS STEEL RETAINING PIN
PURE WATER OUTLET
PREFILTER TUBING - 2"
PURE WATER TUBING - 6"
MICRON RATING
0.1 NOMINAL
(0.4 ABSOLUTE)
PREFILTER (optional)
SOURCE WATER TUBING - 14"
PUMP INLET

Schematic: First Need®

naturally clog the maxtrix much faster. A rate of one pint per minute is suggested. The unit weighs about 16 ounces; it should not be connected at any time to a pressurized water system nor should it be allowed to freeze. Freezing will not destroy the unit, but it must be thawed completely before use, otherwise it will not deliver pure water. If it is dropped, the structured matrix could break; the filter will be useless. The First Need unit does not use a ceramic filter but is rather a proprietary structured matrix comprising submicron microstrainers, pharmaceutical grade activated carbons and molecular sieving materials. This matrix can be broken loose by dropping, but it is much more resistant to breakage than, for example, a ceramic filter.

The device has been greatly improved since first it was marketed. It consists of the purification canister, the pump and a new, ergonometrically-designed pump tee-handle. The canister and the pump are mounted together for ease of operation. Furnished also is a 6 inch pure water tubing and a 14 inch piece of tubing used at the intake. To keep the unit dust free and clean during storage, it comes with a water-repellant tote bag.

An option availabe for both the original device and the new Deluxe model is a "prefilter", which is placed between the intake tubing and the pump. The prefilter eliminates particles down to 10 microns — protecting the pump, giving it longer life and increasing the useful life of the purification matrix. The prefilter which weighs a scant 1-2 ounces in nylon and can be backwashed (cleaned) many, many times.

For those who have the original First Need® units General Ecology has thoughfully provided an enhancement kit which will upgrade the older unit (except for the pump) to the state of the Deluxe model.

The First Need® purifier has been subjected to many evaluations by respected laboratories world-wide. Better than that, the unit has been given many tough, demanding "field use" tests by survey teams, the military, scientific expeditions and many climbing and boating trips. Notable among them are the Sino/USA Upper Yangtze River Expedition (1986), and the U.S.A. — Uttar Gange Expedition II. Several Mt. Everest expeditions carried the unit. It is the standard equipment for the University of Miami Field Epidemiology Survey Team, which travels extensively in remote areas of the Third World.

Further, the First Need® purifier has been selected by the military for nuclear, biological and chemical warfare defense purposes, for which, let us pray, it will never be needed.

The First Need® delivers pure water on both up and down strokes of the pump handle. Perhaps of minor importance, you say, but it does save time and energy at the end of a long day of paddling.

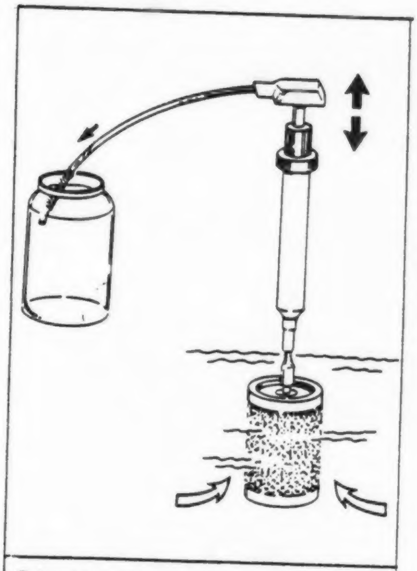
For storage between trips, use a dilute solution of household bleach (Clorox), 1/8 teaspoon per pint of water. More is less! Pump it into the cannister and pump out all "loose" water left in the unit.

If it is desired, as a personal convenience in using the filter, a piece of 3/8" I.D. plastic tubing can be fitted to extend the inlet tubing. A piece of 1/4" I.D. tubing can be fitted to the canister outlet. This will make it a lot more comfortable to operate the unit; no need to stoop and squat. Sit on a stump and pump.

There are reams of technical data available from General Ecology, showing how effective their unit really is. Laboratory studies too long and involved for this space show how efficiently the unit removes those many little nasties all waiting to lower the boom on the hapless one who just can't or won't wait for filtration before imbibing that cool, sparkling water floating his canoe up in Lake Ukintipovurtu. Ask for the proof if you insist. Table III shows comparative test data for the three units studied.

There is no need to clean the First Need canister. When it is showing evidence of need for replacement, simply change it. All bacteria, cysts, chemicals, pathogens of whatever nature are sealed within the canister. There is no need to fear contact between your person and the cantankerous little rascals who cause so much trouble.

The Timberline Filter. This relatively new entry into the market place is ultra-light. It provides protection against Giardia and other organisms of size equal to or larger than amoeba and tapeworm eggs.



Schematic of Timberline filter in operation. You can use it from a canoe.

I did not try deliberately to break the filter — why destroy something which might prove useful? The literature provided by the company states the filter is practically indestructible. (I'll let my 5-year-old grandson do that part of the evaluation.) It is lightweight, (6-7 ounces) and it does not affect the taste of the filtered water. (Any filter worth its salt would improve the taste of water.) The claim is made it will filter particles and microorganisms down to a nominal size of 2 microns. That would probably put the absolute in the range of 5-6 microns. (It seems necessary for Timberline to provide a filter that bars passage of pathogens down to 0.1 micron nominal.)

The normal use for the Timberline is as a pump. In that mode, it is very easy to operate.

To use the Timberline, it is first necessary to connect the various parts of the unit. Not particularly difficult, but the printed instructions furnished with the unit could be more precise. Pumping rate should not exceed 1 quart in 1.5 minutes, a comfortable rate. The

Timberline should be used in a vertical position during the pumping operation to ensure proper action the ball check valve in the pump.

The Timberline should have a filtering capacity of 400 quarts — less, of course, if the water is very heavily polluted and/or laden with debris. When the filter plugs up, the pressure drop will result in low filtration and replacement of the filter unit is mandatory. The company literature shows the filter matrix in use lying on the stream bed. This perhaps could lead to premature failure of the filter matrix. It is doubtless going to pick up bits of sand and debris. All filters require care; Timberline is no exception to the rule. The filter is said to be made of material which will not support bacterial growth; however, it is best to be on the safe side and dry the filter if it is to be stored for an extended period of time, i.e., several months or longer. Remove the filter assembly, taking off the clear plastic tubing and place the assembly in an oven, 175°F for 6 hours. The filtration unit will be dry. The company also claims such prolonged exposure to heat will destroy most micro-organisms present. (Bear in mind that algae, fungi or mold spores can survive in a moist filter, thereby destroying the taste of filtered water.)

Colorado State University's Department of Pathology has conducted tests of the filter with some favorable results. Using three units, they evaluated the efficiency of the filter in removing live infectious cysts (Giardia) from water. Without a detailed description of the tests (conducted according to accepted procedures), let it be said that the Timberline filtered out the disease-bearing cyst pathogens. The laboratory stated: "the filters were 100% efficient in removal of Giardia cysts."

The same laboratory tested the filter against coliform bacteria, *Escherichia Coli*. Again, standard test methods were used. Filter No. 1 removed 39% of the available coliform organisms. Filter No. 2 removed 24.6% of the *E. Coli*. The combined efficiency of both filters was 31.8%, or roughly 1/3 of the available *E. Coli* were trapped. This means 2 out of 3 of those infamous little devils escaped into the filtered water. Certainly, Timberline must try to improve this rate of retention of water-born pathogens.

The Katadyn Pocket Filter. The Katadyn filter is indeed most impressive and exquisitely made. With its' built-in pump it will develop the pressure needed for rapid filtration and can produce just under one quart per minute. This time will vary, of course, as the filter matrix becomes more and more clogged.

It is a compact unit, 10 inches long, 2 inches in diameter, weighing just about 24 ounces. A silver lining on the *inside* of the ceramic filter (the heart of the Katadyn) prevents the growth of bacteria. No chemicals are added to the water and none are removed. Salt water should not be filtered; the Katadyn just won't desalinate. Further, salt combines with the silver to form silver chloride which destroys the effectiveness of the silver placed in the filter unit.

A 20-inch suction hose fitted with a strainer on the intake end to eliminate coarse particles is inserted in the water to be purified.

Manufactured in Switzerland, the Katadyn uses the simple principle of microstraining through a 0.2 micron (nominal) microporous filter element. Harmful cocci, bacteria protozoas, fungi, cysts and parasites are removed, entombed in the ceramic maxtix.

Except for cleaning the ceramic surface for storage and when it is used with watercontaining sediment, the unit requires only an occasional dab of Vaseline on the pump O-ring. Between trips or for longer-term emergency preparadedness, the filter should be disassembled, cleaned and air-dried to be sure the element is completely dry. An instruction sheet — a rather complete one at that —

The Katadyn Pocket Filter.

gives detailed instructions on proper use and maintenance.

The Katadyn Pocket Filter, as with all such equipment, will, upon extended use, show an appreciable loss in water output. The Katadyn can be restored to "full output" by brushing the surface of the ceramic element. A brush is provided for this purpose, as well as a small plastic "caliper" to show when brushing has, over time, taken off more of the matrix than is safe for proper filtration. The manufacturer claims the element can withstand brushing about 300 times before the element becomes too thin for proper removal of pathogens. The element must then be replaced.

It is important to note here that to clean the ceramic element, the Katadyn filter must be taken apart, in itself a simple task. Of greater importance — and this must be clearly understood — in cleaning the element with the brush provided, all the collected contaminants may be dispersed into the air, onto your person, and perhaps ingested by breathing or splashing. This bothers me. Maybe more than it should, but it still chafes. All the contaminants you have so carefully collected are now re-introduced in your presence, just as viable and as deadly as ever. It seems rather inappropriate to collect countless thousands of pathogens on a filter then open the unit and deliberately scrape them off the matrix, allowing them to be once again present to person, cookset, water carrier, friends and perhaps a stream nearby. These pathogens should be kept entombed in the filter matrix and discarded properly. This is the one negative found with the Katadyn filter. In this respect, I find the First Need® unit superior.

The Katadyn has been thoroughly tested by respected laboratories world-wide, including Harvard University, The Swiss Tropical Institute, the Pasteur Institute, the University of Michigan and London's Ross Institute of Tropical Hygiene. Further, many health organizations approved the use of the Katadyn, including the International Red Cross, World Health Organization and UNICEF.

The armed forces of Colombia, India, Portugal, Rhodesia, South Africa, Sweden, Switzerland and West Germany have issued some of the Katadyn filters to their soldiers. It is not known whether or not it is standard issue; in fact, First Need® purifiers also have been issued to some of these armed forces.

This is a very impressive list for a filter that apparently has only two major disadvantages, the manner in which the filter element is cleaned and the fact that it does not *claim* to remove chemical warfare agents. There is no doubt, from all the laboratory data available, that the Katadyn filter does a remarkable job of removing from water the pesky little devils that are anxious to lay us low. The company will give you whatever data you desire; just ask for it.

* * * * * *

For further information on the purification device of your choice, feel free to write or call these manufacturers:

First Need® Purifier

General Ecology, Inc.
151 Sheree Blvd.
Lionville, PA 19353
(215) 363-7900
Contact: Richard Williams

Timberline Filter

Timberline Filter
P.O. Box 12007
Boulder, CO 80303
(303) 494-4104
Contact: Arnold Williams

Katadyn Pocket Filter

Katadyn USA, Inc.
3020 N. Scottsdale Road
Scottsdale, AZ 85231
(602) 990-3131
Contact: Herbert A. Koelble

Table III
Comparative Effectiveness Of Filters And/Or Purifiers

Contaminants	First Need	Timberline	Katadyn
Enteric amoeba	None detected		None detected
Entamoeba histolytica	None detected		None detected
Entamoeba invadens	None detected		None detected
Escherichia coli	None detected	39% removed	None detected
Giardia lamblia	None detected	None detected	None detected
Fecal coli form	None detected		None detected
Salmonella typhosa	None detected		None detected
Shigella dysenteriae	None detected		None detected
Radioactive fallout	None detected		97% reduction in radioactivity
Streptoccocus faecalis	None detected		None detected
Pseudomonas aerugunosa			None detected
Vivrio cholera	None detected		None detected
Pesticides, herbicides	None detected		
Asbestos fibers	None detected		
Dirt and sediment	None passed	None passed	None passed
Foul tastes and odors	Removes	?	?
Chlorines	Removes	?	?
Hydrogen sulfide	None detected	?	?
Volatile organics	Removed	?	?
Chloroform (60 PPB)	97% removed	?	?
PCB's	None detected	?	?
Arsenic, cadmium, lead, mercury, methyl mercury	None detected	?	?

It is almost a matter of having to say "never say never". The data in this table are taken from a wide variety of tests at various reputable laboratories throughout the United States and Europe. To say any unit removes 100% of any contaminant is to beg the question; it appears best to say "none detected". Where there are blanks in the table, it means either there has been no such test or data have not been given me. Where a "?" appears, this is to indicate that such data as I have does not indicate those units are effective in removing such things as organic chemicals, etc.

Health and Welfare Canada
Santé et Bien-être social Canada

Drinking Water Away from Home

Drinking water is not usually a concern when at home, but in the great outdoors it can make you ill. The Health Protection Branch of Health and Welfare Canada wants to help you avoid health hazards. So if you camp, backpack, sail or if you take trips by bike, canoe or recreational vehicle or even if you use a cottage, ensure the water you drink is safe by following these precautions.

Avoid drinking water from sources with visible signs of pollution from industry, agricultural practices and other sources.

Disinfect all water taken from lakes, rivers, mountain streams and ponds no matter how clean it looks. Water may contain invisible but harmful organisms called pathogens. These bacteria, fungi, viruses, protozoan cysts and worm eggs may cause mild nausea and fever or develop into severe diarrhea, hepatitis or typhoid fever. Another invisible pathogen is the protozoan cyst *Giardia* which causes "Beaver Fever." *Giardia* is carried in the feces of many domestic and wild animals (including beavers) and contaminates the water. Commonly found in Canadian surface water, these cysts are quite resistant to chemical disinfection methods. Boiling for several minutes will kill protozoan cysts.

Periodically clean and rinse tanks and containers used to store water. Water treated with chlorine or iodine remains drinkable for several days without refrigeration, while water treated by other means is best used within two days.

Use only good drinking water for brushing teeth.

Have cottage drinking water tested by a provincial or private laboratory if it is not municipally treated. It would be wise to disinfect surface water even if it passes these laboratory tests as not all pathogens can be detected.

When in doubt, boil the water for 5 minutes.

Environmental Health Directorate
Health Protection Branch
1986

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Cat. No. H49-15/10-1986E

EMERGENCY OR SHORT-TERM WATER DISINFECTION

Method	Directions	Advantages	Comments
Boiling	Bring to a boil, allow to cool.	Kills all known pathogens.	Water that has been boiled for coffee or cooking is also safe.
Disinfection Tablets	Use as directed.	Usually effective if directions are carefully followed.	If water is very cold, allow extra time before drinking.
Chlorine Bleach	Add 2 drops (0.1 mL) per litre of water (or 4 drops if water is turbid). Mix, let stand at least 30 min.	Usually effective if water is not too alkaline.	If water is very cold, allow extra time before drinking.
Tincture of Iodine (2%)	Add 5 drops (0.25 mL) per litre of water (or 10 drops if water is turbid). Mix, let stand at least 30 min.	Usually effective.	If water is very cold, allow extra time before drinking. Do not drink water for more than a few days at a time.

ROUTINE WATER DISINFECTION FOR COTTAGES, RECREATIONAL VEHICLES, ETC.

Method	Directions	Advantages	Comments
Chlorination	Chlorine bleach is dosed into the water by a pump. Adequate contact time is ensured by a storage tank.	Effective against most pathogens.	May require additional filters to eliminate *Giardia* cysts. Can treat large volume of water.
Distillation	Water is treated in a still to kill pathogens.	Kills all known pathogens.	Suitable for small quantities of water.
Iodination	Iodine is dosed into the water. Adequate contact time is ensured by a storage tank.	Effective against most pathogens.	May require additional filters to eliminate *Giardia* cysts. Can treat large volumes of water.
UV Irradiation	Water passes by a UV-lamp that inactivates pathogens.	Effective against all except most resistant organisms. No change in water taste.	Requires additional filters to eliminate *Giardia* cysts. May only be partially effective if water is turbid.
Ceramic Filtration	Water passes through a porous ceramic cartridge that removes particles.	Likely to be effective for cysts and bacteria.	May be only partially effective against viruses.
Ozonation	Ozone is formed and bubbled through the water.	Effective against most pathogens if dosage is sufficient.	May require additional filters to eliminate *Giardia* cysts.

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Canada

Health and Welfare
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L'eau consommée à l'extérieur du foyer

De façon générale, vous n'avez pas à vous soucier de l'innocuité de l'eau que vous buvez à la maison, mais en pleine nature, l'eau que vous consommez peut vous rendre malade. La Direction générale de la protection de la santé du ministère de la Santé nationale et du Bien-être social veut vous aider à éviter tout danger pour la santé. Ainsi donc, que vous fassiez du camping, de la randonnée pédestre ou de la voile, que vous partiez à bicyclette, en canoë ou en caravane motorisée ou que vous logiez dans un chalet, vous devez toujours vous assurer que l'eau que vous buvez ne présente aucun danger. Voici quelques précautions à suivre:

Éviter de boire de l'eau qui peut être insalubre et polluée en raison de déchets industriels, agricoles ou autres.

Même si elle vous semble propre, toute eau de surface, qu'elle provienne d'un lac, d'une rivière ou d'un étang, doit être désinfectée. L'eau peut contenir plusieurs types d'organismes invisibles à l'oeil nu mais tout aussi nocifs; il s'agit de bactéries, de champignons, de virus, de kystes de protozoaires et d'oeufs de vers, qui peuvent causer des nausées et une fièvre bénignes ou entraîner une forte diarrhée, une hépatite ou la fièvre typhoïde. On peut se débarrasser de ces microorganismes en désinfectant l'eau. Il faut aussi se méfier de la "fièvre des castors" causée par le protozoaire *Giardia*. Ce protozoaire invisible à l'oeil nu peut contaminer des sources montagneuses par ailleurs d'excellente qualité. De nombreux animaux domestiques ou sauvages (en plus du castor) abritent le *Giardia* dans leurs selles et contaminent l'eau. Ces kystes, que l'on trouve souvent dans l'eau de surface au Canada, peuvent y survivre pendant des mois et résistent assez bien aux méthodes de désinfection. Il s'agit donc de faire bouillir l'eau pendant quelques minutes pour éliminer les kystes de protozoaires.

Il importe de nettoyer et de rincer périodiquement les réservoirs et contenants dans lesquels on conserve l'eau. L'eau dans laquelle on a ajouté du chlore ou de l'iode reste bonne à boire plusieurs jours sans réfrigération. Toutefois, il est préférable de consommer en dedans de deux jours l'eau qui a été désinfectée autrement.

Se brosser les dents uniquement avec de l'eau potable.

Les propriétaires de chalets (ou de maisons à la campagne), de même que les personnes qui ne tirent pas leur eau de boisson d'un aqueduc municipal, devraient faire analyser leur eau de boisson. Des laboratoires provinciaux ou privés peuvent s'en charger. Toutefois, comme les méthodes utilisées présentement ne permettent pas de déceler la présence de tous les organismes pathogènes pouvant se trouver dans l'eau, il serait bon de désinfecter l'eau de surface avant de l'utiliser, même si elle semble toujours bonne d'après les analyses de laboratoire.

En cas de doute, faire bouillir l'eau pendant cinq minutes.

Direction de l'hygiène du milieu
Direction générale de la protection de la santé
1986

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N° de cat. H49-15/10-1986F

DÉSINFECTION D'URGENCE DE L'EAU

Méthode	Instructions	Avantages	Observations
Ébullition	Porter à ébullition et laisser refroidir.	Tue tous les agents pathogènes connus.	L'eau bouillie pour le café ou la cuisson ne présente aucun danger.
Comprimés de purification	Suivre les indications.	Habituellement efficace si l'on suit attentivement les modes d'emploi.	Si l'eau est froide, attendre un peu plus longtemps avant de la boire.
Chlore (Javel)	2 gouttes (0,1 mL) par litre d'eau, ou 4 gouttes si l'eau est trouble. Mélanger et laisser reposer au moins 30 min.	Habituellement efficace si l'eau n'est pas trop alcaline.	Si l'eau est très froide, attendre un peu plus longtemps avant de la boire.
Teinture d'iode (2%)	5 gouttes (0,25 mL) par litre d'eau (ou 10 gouttes si l'eau est trouble). Mélanger et laisser reposer au moins 30 min.	Habituellement efficace.	Si l'eau est très froide, attendre un peu plus longtemps avant de la boire. Ne pas en boire plus de quelques jours à la fois.

DÉSINFECTION SYSTÉMATIQUE DE L'EAU ALIMENTANT LES CHALETS, CARAVANES MOTORISÉES, ETC.

Méthode	Instructions	Avantages	Observations
Chlorination	Utiliser une pompe pour doser l'eau de Javel. Un réservoir d'attente assure une chlorination suffisante.	Efficace contre la plupart des agents pathogènes.	Des filtres additionnels peuvent être nécessaires pour éliminer les kystes de *Giardia*. Peut convenir à de gros volumes d'eau.
Distillation	Eau traitée dans un alambic dans le but de tuer les pathogènes.	Tue tous les agents pathogènes connus.	Bon pour de petites quantités d'eau.
Iodation	Dosage de l'iode dans l'eau. Un réservoir d'attente assure une iodation suffisante.	Efficace contre la plupart des agents pathogènes.	Des filtres additionnels peuvent être nécessaires pour éliminer les kystes de *Giardia*. Peut convenir à de gros volumes d'eau.
Irradiation UV	L'eau passe devant une lumière UV qui rend les agents pathogènes inactifs.	Efficace contre tous les organismes sauf les plus résistants. Ne modifie pas le goût de l'eau.	Des filtres additionnels sont nécessaires pour éliminer les kystes de *Giardia*. L'eau doit pouvoir se prêter à ce traitement.
Filtrations sur cartouche de céramique	L'eau passe dans une cartouche de céramique qui retient les particules.	Devrait éliminer les kystes et les bactéries.	Ne s'avère pas toujours efficace contre les virus.
Ozonisation	Le gaz ozone est injecté dans l'eau.	Efficace en concentration suffisante contre la plupart des agents pathogènes.	Des filtres additionnels pourront s'avérer nécessaires pour éliminer les kystes de *Giardia*.

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